Clinicians' Perception of the Benefit from Orthognathic Surgery in Patients of Different Racial Background Presenting with a Class III Skeletal Discrepancy

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Abstract

Aim: To investigate the impact of patients' race on influencing whether clinicians perceive benefit from orthognathic surgery in patients with class III skeletal bases.

Design: Cross-sectional study.

Methods: This study involved sending questionnaires to all consultant orthodontists and maxillofacial surgeons in the United Kingdom using the mailing list from British Orthodontic Society and British Association of Oral and Maxillofacial Surgeons. The questionnaires were sent using a sequential mixed mode approach for the Consultant Orthodontists group and a web-based mode for the Oral and Maxillofacial Surgeons group. The questionnaire used silhouettes of two patients (one Caucasian and one Chinese). These were manipulated to produce a class III skeletal discrepancy. The maxillary position of the selected normal profile silhouettes was manipulated posteriorly from the normal position, in 2 mm increments up to 10 mm. The mandibular position, of the selected normal profile silhouettes, was manipulated anteriorly from the normal position, in 2 mm increments up to 10 mm. A total of 26 silhouettes were constructed. The participants were asked to spend no more than 30 seconds looking at the silhouettes and answer the following questions: "Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?" and "How do you rate the level of attractiveness of the profile?"

Results: There was no statistically significant difference between the perception for the benefit from orthognathic surgery between Consultant Orthodontists' and Consultant Oral and Maxillofacial Surgeons ($p=0.176$). The silhouette's race was featured as highly statistically significant factor predicting the perceived benefit from surgery ($p<0.001$). The odds of clinicians perceiving a benefit from surgery and therefore recommending an orthognathic surgery approach increased 2.87 times for a Chinese silhouette compared to a Caucasian silhouette with class III skeletal bases. Consultant's years of experience, gender, specialty, the number of orthognathic patients treated per year, and the consideration of the importance of an attractive appearance were not statistically significant factors predicting perceived benefits from orthognathic surgery.

Conclusion: Clinicians perceived benefit from orthognathic surgery in patients with class III skeletal bases was significantly higher for Chinese silhouettes than for Caucasian silhouettes with the same degree of manipulation. The Caucasian ideal profile was considered more attractive than the Chinese ideal profile.

Keywords: orthognathic surgery, class III skeletal profile, Chinese, Caucasian, facial attractiveness, clinical decision making

Research Communication

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1 Introduction

A dental malocclusion can compromise attractiveness and, therefore, demand for treatment is common. Studies done by Shaw *et al*.[1], Kerosuo *et al.* [2], Birkeland *et al.* [3] and Kiekens *et al.* [4] suggest that orthodontic patients and their parents believe that having well-aligned teeth is an important factor in facial appearance. According to these researchers, patients and their parents believe that orthodontic treatment can contribute to popularity and social success by improving dental, dentofacial and facial aesthetics.

Orthodontic treatment is limited by the boundaries of the dentoalveolar bone, the underlying jaw discrepancy, the soft tissues and the growth potential[5]. The extent to which the lower incisors can be moved relative to the dentoalveolar bone is very critical. According to Mills, the lower incisors lie within a narrow zone of stability and he advises that this position should not be altered[6]. This is due to the fact that any attempts to move incisors beyond the zone of stability would be highly unstable and may cause gingival recession and more potential for relapse. In addition, the result would not be aesthetically pleasing if the lower incisors were advanced significantly.

Dental malocclusions can be managed through the use of fixed appliance treatment or growth modification[7]. Patients suffering from significant skeletal disharmony or dental problems, which are not easily treated due to a lack of growth, are often offered a combined surgical and orthodontic approach[7]. Orthognathic surgery is an alternative treatment option for patients presenting with dentofacial deformities[7]. It has a significant impact on facial aesthetics. Therefore, in order to plan surgery for these patients, it is necessary for orthodontists and oral and maxillofacial surgeons to share the same clinical guidelines with mutually agreed clinical criteria, which enable them to plan the most appropriate treatment for their patients[8].

The planning of orthodontic treatment should follow a detailed and accurate assessment of facial measurements and a patient's needs[7]. Ideally, there should be a uniform, universally accepted method of measuring these components. However, it can be easier to describe what is abnormal rather than to define the characteristics

that make a face acceptable or unattractive. This problem can present more challenges to clinicians when considering different racial groups.

Certain types of malocclusions, especially class III skeletal pattern, often present with unfavourable growth patterns which contributes to the facial and skeletal discrepancy[9]. The prevalence of this type of malocclusion in White populations is lower than 5 per cent but it rises to as high as 12 per cent in Chinese and Japanese populations[10]. A combination of retruded maxillary position and prognathic mandible [9] is the most common cause for this type of malocclusion. The preferred treatment choice for this group of patients often involves a combination of orthodontic and orthognathic surgery. It is uncertain whether the clinicians appreciate the differences in patients' racial norms or whether they treat all patients according to the Caucasian facial norms. At what point does a class III skeletal discrepancy become unattractive and is this the same for Caucasian and Chinese patient groups? Moreover, do orthodontists and oral and maxillofacial surgeons view this the same way? There are generally agreed norms for facial proportions in different forms including cephalometric analyses, anthropometric measurement and even artistic views[11] [12]. However, it is uncertain whether clinicians' use particular criteria or whether they plan solely on intuition and personal preference[11] [12].

2 Literature Review

2.1 Orthodontic Treatment

"Orthodontics is the branch of dentistry concerned with growth of the face, development of the occlusion and the prevention and correction of the occlusal anomalies" [13]. An important objective of orthodontic treatment is to improve facial aesthetics by achieving an ideal occlusion. An ideal occlusion cannot be achieved if there is a significant underlying skeletal discrepancy.

There were a various attempts in the literature to define the ideal occlusion. Edward Angle who is the father of modern orthodontics was the first to develop the concept of occlusion[14]. Angle classification had four classes: normal occlusion, Class I malocclusion, Class II malocclusion and Class III malocclusion. This was based on the molar relationship of the dentition[14]. In normal occlusion, the buccal cusp of the upper first molar should occlude in the lower groove of the lower first molar. Angle believed that if the molar relationship was correct and the teeth were arranged on a smooth curving line of occlusion then a normal occlusion would result. This statement is correct as long as there is no discrepancy in the ratio between the size of the teeth and the size of the jaws.

A Class I malocclusion is defined as a normal molar relationship but where teeth are rotated or are malpositioned leading to an incorrect line of occlusion[14]. Class II malocclusion occurs when the lower first molar occludes distally to the upper first molar. Class III malocclusion presents when the lower first molar occludes mesially to upper the first molar[14]. The drawbacks of Angle's classification are that if the molars are absent, the classification cannot be applied nor does it describe the skeletal relationship present.

Andrews described the requirements of an ideal static occlusion after observing 120 study casts of patients with normal occlusions[15]. Andrews' sample comprised non-orthodontically treated subjects. He found that in order to have an ideal occlusion, six

characteristics should be present in the occlusion. He called them the six keys of normal occlusion[15].

These keys were:

- Correct molar relationship
- Correct crown angulation
- Correct crown inclination
- No rotation
- Tight contact points
- Flat curve of Spee

These six keys are currently used to assist orthodontists to achieve the correct tooth position from an aesthetic and dental health point of view[15]. However, patients are more concerned with their incisors rather than the buccal segment relationship and so the most widely used classification system is actually an incisor classification[13]. This is based on the relationship between the lower incisors edges and the cingulum plateau of the upper central incisors. The classification is divided into Class I, Class II division 1, Class II division 2 and Class III incisal relationships[16]. A Class I incisor relationship is present when the lower incisors occlude on or below the cingulum plateau of upper incisors and it is present in 60% of UK population[16] [17]. A Class II is defined as the lower incisors occlude palatally to cingulum plateau of the upper incisors. If the upper incisors are proclined or at an average inclination then this is classified as a Class II division 1 incisor relationship; and if the upper incisors are retroclined then this is classified as a Class II division 2 incisors relationship[16]. The prevalence of Class II division 1 and 2 in the UK population is 20% and 18% respectively[17].

Orthodontists have found that even when an excellent occlusion is obtained during orthodontic treatment; the results of treatment are unsatisfactory for certain group of patients such as these with an underlying skeletal discrepancy[7]. Thus a skeletal classification system of malocclusion has been developed which often corresponds to the dental classification system but they must be assessed separately[13].

Skeletal classifications are based on a profile view and are divided into class I, class II and class III skeletal patterns [13]. A class I skeletal relationship is considered to

represent the ideal skeletal relationship and is sometimes called the orthognathic profile. A class II skeletal discrepancy is the result of a discrepancy between the maxilla and the mandible and leads to a convex facial profile. This is usually due to a large (prognathic) maxilla or a small (retrognathic) mandible. On the other hand, class III skeletal discrepancy can be the result of a discrepancy between the maxilla and the mandible leading to a concave facial profile. This is usually due to a prognathic mandible or a retrognathic maxilla[13].

In orthodontics, there are three options for treating a malocclusion with an underlying skeletal problem. The first option is growth modification, which is the use of a functional appliance in adolescents to enhance or retard the growth of the jaws with the aim of correcting the underlying skeletal discrepancy[18]. During facial growth, the jaw relationship is altered such that there is an average tendency for the mandible to grow more than the maxilla[7]. This differential growth improves class II but worsens class III skeletal discrepancies. In class III cases, the mandible continues to grow more and for longer than in class I malocclusion[9]. Therefore, class II skeletal discrepancy is easier to modify in adolescents using functional appliances than is a class III skeletal discrepancy[18].

The second treatment option is orthodontic camouflage. This option involves the movement of teeth relative to their supporting bone in order to compensate for the underlying skeletal discrepancy[19]. However, the more severe the skeletal deformity is the more difficult it is for orthodontists to manage the case using orthodontic camouflage. For example, if you try to camouflage a moderate class III skeletal discrepancy with orthodontic treatment alone, the patient may end up with a more prominent chin and consequently will not be satisfied with the outcome of treatment[19]. Thus there is a limitation to what can be achieved using orthodontic treatment alone[19] and therefore some patients may benefit from combined orthodontic/orthognathic treatment, which is the third treatment option.

2.1.1 Limitations of Orthodontic Treatment

Deformities of the jaw or mid-face result in disharmony in the positions of the dentition and the overall occlusion. This can result in aesthetic and functional concerns for the patient. An element of “dento-alveolar compensation” can occur; when the dentition varies from a normal position as a means of achieving a more functional occlusal contact; attempting to counteract and mask the underlying skeletal discrepancy. As the underlying pattern of bony growth and development is the cause for the mal-alignment of teeth, alignment of the teeth alone is often not sufficient to improve aesthetics of function for these patients; the underlying skeletal pattern needs addressing. As discussed earlier, there is a generally agreed concept that it is easier to camouflage a mild to moderate class II skeletal discrepancy than a mild to moderate class III skeletal pattern. There have been attempts in the orthodontic literature to describe the limits for camouflage orthodontic treatment. It has been found that attempts at camouflage in severe cases results in an increase in treatment time and compromise in the final outcome[5].

Orthodontic treatment is limited in its application to achieve orthopaedic changes[19]. The ability to use orthodontic appliances alone as means to correct and underlying skeletal discrepancy is an area of much controversy[20]. The use of functional orthodontic appliances can manipulate the environmental factors associated with growth and therefore can potentially influence more favourable growth to correct underlying skeletal malocclusions. Taking class II skeletal relationships as an example, the main aim of functional appliances here would be to induce growth modification and lengthening of the mandible by stimulating growth at the condylar cartilage[21]. How successful the functional appliances are would be dependent on the direction and amount of growth at the condylar cartilage, which in turn depends on the growth rate of patient. In addition, treatment aimed at enhancing or restraining maxillary growth is more efficient when tackled before the adolescent growth spurt[22]. Because of this, functional appliances are regularly used in this manner as a means of influencing growth and eliminating the future benefit from surgery. However, despite the long history of functional appliance usage in orthodontics, there continues to be much debate relating to their use, mode of action and effectiveness. There is no doubt that functional appliances can rapidly correct certain

malocclusions, however this change is thought to be mainly dento-alveolar[23]. As a result, relapse, adverse growth or inappropriate referral timing can mean that patients are unsuitable for functional appliance treatment, and so management of the underlying skeletal malocclusion or dentofacial deformity is only made possible through orthognathic surgery [24].

The 'three envelopes of discrepancy' refers to clinical guidelines, proposed by Proffit *et al*.[27], to help define the limits of camouflage, growth modification and combined surgical treatment. It describes the ideal position of the upper incisors, shown by the origin of the x and y axes . This identifies the amount of change that can be achieved with: orthodontic tooth movement alone (the inner envelope of each diagram); orthodontic tooth movement combined with growth modification (the middle envelope); and orthognathic surgery (the outer envelope). It should be noted that the possibilities for movement in each direction are not symmetrical. There is more potential for the teeth to be moved forwards than backwards and more potential for extrusion than intrusion. Since the growth of the maxilla cannot be modified independently of the mandible, the growth modification envelope for the two jaws is the same. There is only a 10 mm potential for moving the maxilla forwards. Surgery to move the mandible backwards has more potential than surgery to advance it by 25 mm and 12 mm respectively.

The influence of soft tissues on the decision about whether to undertake orthodontic treatment or orthognathic surgery is not reflected in Proffit's envelope of discrepancy. The soft tissues include the periodontal ligaments, lips, cheeks, tongue, muscles etc. The effect of soft tissue can be limiting[5]. Patients who would require a large mandibular set back as part of their orthognathic surgery should be aware that this may result in redundant soft tissue forming folds at the lower margins of the mouth and in the submental area[27]. In some cases another surgery may be required to remove the excess soft tissue. In addition, large maxillary advancement surgery can result in widening of the alar bases and upturning of the nasal tip. This might render some patients from having this procedure[27].

2.1.2 Orthognathic Surgery

"Orthognathic surgery is that branch of surgery concerned with the correction of dentofacial deformity, and particularly with disproportions of the tooth-bearing segments of the jaws and associated facial skeleton"[13]. It is a branch of surgery, which was first introduced by Vilray Blair, a famous plastic surgeon who worked with Edward Angle at the beginning of the last century. The aim of orthognathic surgery is to correct the functional and aesthetic consequences of severe facial deformities. However, research has shown that most patients who request orthognathic treatment are concerned about their facial appearance and not their poor masticatory functions[28-30]. The majority of patients requesting orthodontic treatment suffer from mild to moderate facial deformity[31]. It was found that this group of patients suffers more psychological distress than those who have severe facial deformities[31] [32]. This is due to the fact that people's reactions towards milder deformities are inconsistent compared to their reactions to severe facial deformities, which tend to provoke more predictable responses[31] [32].

Orthognathic surgery plays a vital role in the correction of malocclusions and dentofacial deformities, which lie outside the realms of management with orthodontic treatment alone. Although orthognathic surgical techniques have been described in the literature since the late nineteenth and early twentieth centuries[33] [34], advances in osteosynthesis materials[35], orthodontic appliances and anaesthesia, in addition to an improved understanding of case assessment and selection[36], have contributed to a reduction in surgical morbidity[37] and the subsequent increasing practice of combined orthodontic and surgical intervention over the past four decades. Orthognathic surgery has therefore assumed an important role in modern day orthodontics, as a means of providing functional and aesthetic changes to patients who would have otherwise had a poor or compromised outcome[38]. However as a result of its increasing popularity and availability, there has been a subsequent increasing interest in exploring the impact it has on patient satisfaction with the surgical outcome[39]. Therefore, this section will discuss the surgical techniques and the patients' satisfaction of orthognathic surgery.

Surgical techniques

Since orthognathic surgery has become a routine procedure for the correction of certain malocclusions alongside adjunctive fixed orthodontics therapy, surgical techniques have developed rapidly. The most common surgical procedures for the correction of skeletal malocclusions can be categorised as maxillary procedures or mandibular procedures; which can be carried out individually or combined together if the underlying malocclusion warrants it. However categorisation of the variety of procedures which are used is much more complex. The maxilla can be advanced, expanded, impacted or set-down; movements which can be symmetrical and straight, or asymmetric and rotational. In addition this movements can involve the entire maxilla or may be sectional. Furthermore, the mandible can be also advanced or set back, in a symmetric or asymmetric manner [(40)].

Additional orthognathic procedures are often also carried out to enhance and improve the aesthetics or function, for example, distraction osteogenesis, advancement or reduction genioplasty, rhinoplasty, temporomandibular joint procedures and soft tissue augmentation[(41)], Further developments in techniques and materials mean this list is constantly expanding, as too are the cases and patients to whom this type of surgery becomes appropriate. As such, combined surgical management is becoming an area of increasing interest in orthodontic research.

Orthognathic Patients

The most important element when treating orthognathic patients is the joint clinic planning process. A joint clinic consists of an orthodontist, oral and maxillofacial surgeon and sometimes a restorative dentist or psychologist. The aims of the joint clinic are to communicate with the patient, discuss the feasibility of addressing the patient's chief complaint, agree on a provisional surgical plan and discuss the risks of orthognathic surgery[(18)].

Communication between patients and health care professionals throughout the course of treatment has been highlighted as a factor, which can influence how satisfied a patient feels with their outcome and their overall experience. This

includes, not only the quality or quantity of information, which is portrayed to the patient but also the manner in which the information is delivered[42]. Auerbach *et al*[43] found that postoperative satisfaction with surgical treatment may not necessarily correlate with the surgeon's skill, but with a failure in communication between surgeon and patient. Likewise, Olsen and Laskin[44] found that dissatisfaction with surgery was related to an inadequate explanation of procedures rather than the actual outcome itself. Characteristics such as friendliness, consideration, concern, sincerity and patience from a health care professional can influence the patient's satisfaction following an encounter. Conversely, characteristics such as abruptness or disrespect from a health care professional can result in the patient feeling worried, hurt or even insulted, reflecting negatively in the satisfaction[45].

Females are more likely to seek orthognathic surgery than males and previous studies of orthognathic patients approximately two third of the patients were females.[46-49]. This is not a surprising finding because research has shown that women in general utilise medical services more than males[50]. Women with a class III skeletal profile are twice as likely as men to seek a professional opinion about orthognathic surgery [51].

2.1.3 Class III Skeletal Pattern

A Class III incisal relationship refers to when the lower incisal edge occludes in front of the cingulum of the upper incisors[16]. Moreover, a class III skeletal relationship is the result of a discrepancy between the maxilla and mandible leading to a concave profile[10]. This can be due to a retruded maxillary position, prognathic mandible or a combination of both.

The prevalence of this type of malocclusion in Caucasian populations is lower than 5 per cent, but rises to as high as 12 per cent in Chinese and Japanese populations[10]. A relatively high prevalence of class III skeletal discrepancy has also been observed in Mediterranean and Middle Eastern populations[52]. In the United Kingdom, Foster and Day[53] screened British girls aged 11 to 12 years and found

that 1.6 per cent had Class III malocclusion. Another study of the same age group, Haynes[54] reported a prevalence of 3.2 % with Class III malocclusion.

Guyer *et al*.[55], found that 55% of class III skeletal discrepancies involved maxillary deficiency as one of the components of the discrepancy and mandibular prognathism in 45% of cases. In addition, 59% of class III discrepancies are found to have reduced or neutral lower facial heights, whereas 41% had increased lower facial heights. Other clinical features include increased scleral show; malar flattening; malar hypoplasia in mid-face deficiency; paranasal hallowing; an obtuse nasiolabial angle; a reduced view of incisors when smiling and increased buccal corridor dark space[56].

Correction of a Class III malocclusion by means of orthopaedic/orthodontic treatment in growing subjects can be achieved in about 70% of patients[57-59]. Prognostic evaluation of treatment outcomes, based on pre-treatment craniofacial features, has been attempted for patients with a Class III malocclusion. This research[58] [59] shows that a quarter of patients with a Class III malocclusion who have undergone orthopaedic/orthodontic treatment, benefit from surgery once their active growth is complete to correct their underlying dento-skeletal discrepancy, as they have not responded satisfactorily to the orthopaedic/orthodontic therapy.

Orthodontic Class III camouflage is achievable in patients with reverse overjet due to proclined lower incisors or retroclined upper incisors with more maxillary deficiency than mandibular prognathism. The patients should have average to short lower face height. However, these features are rarely seen in patients of European decent and occur more frequently in Asians.

2.2 Racial Anatomical Facial Variation

2.2.1 Race versus Ethnicity

The terms race and ethnicity are often used interchangeably; however, they are not synonyms. Race is defined in the Oxford dictionary[60] as "*a classification system used to categorise humans into large and distinct population or groups by anatomical, cultural, ethnic, genetic, geographical, historical, linguistic, religion,*

and/or social affiliation". This term was first used to refer to speakers of a common language and indicate national affiliations. In the late 17th century, it was used to relate to observable physical traits, which led to social hierarchies favouring one racial group over another. In the 19th century, race was often used to denote genetically differentiated human populations, and therefore tends towards distinguishing people by phenotype[61].

Ethnicity is defined in the Oxford dictionary [60] as "*the fact or state of belonging to a social group that has a common national or cultural tradition"*. It is a socially defined category for people who identify themselves with each other based on common ancestral, social, cultural or national experience. Ethnicity, therefore, differs from race, in the way it is defined. Membership of an ethnic group tends to be defined by a shared cultural heritage, ancestry, myth of origin or even ideology. It also exhibits itself through symbolic systems such as religion, mythology and ritual cuisine, dress style and physical appearance [62].

2.2.2 Racial facial norms

Mr. Broadbent[63] first introduced cephalometric measurements for orthodontics, in 1931. Since then, numerous cephalometric norms or cephalometric standards have been derived for various ethnic populations. Cephalometrics are used for a range of purposes, extending from the study of facial form to the development of cephalometric norms for diagnosis, management and outcome assessment[7].

There are three main areas of deficiencies in cephalometric measurements. First of all, cephalometric are two dimensional representation of three dimensional structures. This affected the measurement in the transverse relationship. Attempts were made to overcome this by taking a Posterior Anterior cephalometric. However, both views represent the dento-skeletal structures and not the soft tissue appearance, which most patients are concerned with. The second deficiency is population details that most cephalometric norms are based on are not clear. Steiner analysis is based on one patient and it is considered one of the highly acknowledged analyses. Also, most cephalometric studies have been based on Caucasian norms,

and it is apparent that it would be inappropriate to apply these norms to different ethnic groups, as racial characteristics lead to important cephalometric variations. Finally, most of the cephalometric analyses are based on a historic sample and it is doubtful their current validity due to the population changes that occurred.

In order to overcome these deficiencies, a comprehensive up to date dataset of three dimensional soft tissue measurements is needed. These criteria fit the anthropometric measurements. Dr. Farkas, a plastic surgeon, introduced anthropometric craniofacial measurement for North American Whites[64-66] and carried out an international anthropometric study of facial morphology amongst various ethnic groups[67]. The study group consisted of 1,470 healthy subjects (18 to 30 years), 750 males and 720 females. The largest group (780 subjects, 53.1%) came from Europe, all of them Caucasians. Three were drawn from the Middle-East (180 subjects, 12.2%), five from Asia (300 subjects, 20.4%) and four from amongst peoples of African origin (210 subjects, 14.3%). In addition to Farkas *et al*. soft tissue norms, Arnett *et al*.[68] proposed a soft tissue analysis to aid diagnosis and treatment planning, based on the clinical finding rather than cephalometric measurement. It was based on 20 Caucasian male and 26 Caucasian female adults. They understood the effect of orthodontic treatment, which can lead to dramatic soft tissue changes, and they called it facial keys. The craniofacial measurements taken by Farkas *et al*. of Caucasian and Chinese individuals are attached in Appendices 9.1 and 9.2 respectively. In comparison to Caucasians, Chinese have a less convex profile, the upper lip is more protrusive, the nasiolabial angle is less obtuse and the maxillary position is retruded[69].

2.3 Perception of Facial Aesthetics

Facial attractiveness has been an object of desire for many centuries[1]. Modern societies place a strong emphasis on facial attractiveness[70][71]. Research has shown that people with attractive features are considered to be more competent socially, successful and likeable[72-75]. It has been challenging for clinicians and patients to understand and communicate what a desirable facial profile is, and what is acceptable, especially when the patient and clinician do not share a similar

background. The studies in table 2.1 investigated the impact of race and culture on the assessment of facial attractiveness.

Table 2.1: Summary of studies looking at the impact of race and culture on assessment of facial attractiveness

Study	Participants (sample size)	Intervention	Results	Conclusion
Martin (1964) [76]	American White (50) vs. American Black (50) vs. Nigerian Black (50)	Rate 10 African female photographs' level of attractiveness	American group share the same aesthetic view that is different than Nigerian group	Dominant culture plays a more important role than race with regards to aesthetic value of individuals
Cross & Cross (1971) [77]	American White (150) vs. American Black (150)	Rate the perceived beauty of 72 portrait photographs	Black participants rated the photo more beautiful than Caucasian	Ethnicity plays a role in aesthetic self perception
Foster (1973) [11]	Caucasian vs. Chinese vs. African American (students, dentists, orthodontists)	7 silhouettes of Caucasian female with varying lip position	Overall preference for a fuller profile in young people except orthodontic group	The mass media effect the perception of beauty
Kiyak (1981) [78]	Caucasian (46) and Pacific Asians (50)	Rate the drawings of various skeletal malocclusions that had Asian and Caucasian features	Pacific Asians were more tolerant of skeletal facial disproportion and tooth spacing than Caucasians	Further research needed to explore effect of culture in dental aesthetic perception
Mantzikos (1998) [79]	2651 Japanese adults immigrated to USA within last 5 years	5 photographs presenting different skeletal pattern	Orthognathic profile was most favoured although Japanese tend to have mandibular prognathism	Effect of mass media and American culture has changed the participants aesthetic views
Mandall *et al.* (1999) [80]	Asian vs. White children	Questionnaire and clinical examination	No difference between the two groups	Ethnicity is not important factor with respect to orthodontic aesthetic self perception in children

Martin[76] carried out a study to determine the relationship between racial-group membership and judgment of female beauty. He aimed to explore the differences in opinion of three groups; American Whites, American Blacks, and Nigerian Blacks. He selected a series of photographs of Black females in order for them to be ranked on the basis of attractiveness. The pictures were taken at random from magazines. In addition, 15 judges, all social scientists, were asked to rank the photographs from most African and least Caucasian features to least African and most Caucasian features. This was in order to allow a comparison between the racial variables and beauty ratings within the three groups. Martin found that American Whites and American Blacks shared a common aesthetic standard: the Caucasian facial model. On the other hand, the Nigerian group rated Caucasian features to be attractive less often than did either of the American groups. This study showed that although American Blacks and Nigerians are from the same racial group, they do not share the same aesthetic views. This suggests it may be more appropriate to apply ethnic norms, rather than racial norms, when making clinical decisions regarding a patient's benefit for treatment, which has an impact on aesthetics.

Cross and Cross[77] also investigated differences in the perception of facial beauty between American Whites and Blacks. They interviewed a sample of 300 people; this included three groups of 80 whose ages were 7, 12, and 17 years respectively, and a group of 60 adults between the ages of 30 and 50 years. Equal numbers of males and females participated and the numbers of Black and White participants were equal in each age group. Participants were asked to rate the perceived beauty of 72 portrait photographs of persons in each of the similar age groups and of both sexes and in each ethnic background. There was no significant difference in perceived beauty between the different age groups. However, they found that there was a significant difference related to ethnicity; the Black group rated the photos to be more beautiful than the White group did. Their findings suggest that the White participants are more critical in terms of judging the facial aesthetic than Black participants group. This study is more than 40 years old now so this finding might not be applicable to current population because of changes in societal norms.

Another study by Kiyak[78], compared the aesthetic values of two groups: American Caucasians and Pacific Asian immigrants (Chinese, Vietnamese, Laotians) in the United States. The sample group included 46 Caucasians and 50 Pacific Asians between the ages of 18 and 60 who were asked to rate line drawings of female profiles in terms of their level of attractiveness. The drawings represented various skeletal discrepancies and dental problems. The dental problems included severe crowding, severe spacing, crooked teeth and normal spacing. One set of drawings represented a Caucasian face and there was another set for the Pacific Asian face. The author found that the Pacific Asians were more tolerant of skeletal facial disproportion and tooth spacing than Caucasians. This study confirms the finding of Cross *et al*[77] study that White participants are more critical about rating attractiveness; giving lower scores than Pacific Asians.

Mandall *et al.*[80] attempted to explore the difference in the perceived aesthetic impact of malocclusion between Asian and White children. An Asian was defined as *"a person who, irrespective of birthplace, would identify him/herself as racially and ethnically originating from peoples indigenous to India, Pakistan, Bangladesh and Sri Lanka. This includes Asians born in East Africa, the UK and Mauritius, but excludes Whites born in India"*. In the study, a random sample of 434 14–15-year-old Asian and White children from schools in Manchester, were asked to fill in a questionnaire. They concluded that ethnicity was not an important factor with respect to orthodontic aesthetic self-perception. These findings contradict some of the studies[77][78] reported above, which indicate that Caucasians may be less tolerant of malocclusion than other ethnic groups. On other hand, this study agrees with Martin's[76] study on American Whites and Blacks because both of these studies show that different ethnic groups living in the same society may share similar aesthetic values. This study is more recent and it is looking at UK population so it is more relevant to us than the previously discussed papers.

Foster[11] carried out a study exploring the perception of facial profile aesthetics amongst dentists, art students, orthodontists, and a population group of African Americans and Chinese Americans. They devised a series of seven facial silhouettes, varying from retrusive to protrusive lips, of an 18-year-old Caucasian girl.

These profiles were constructed by varying the lip position in 2-mm increments from the Ricketts' E-Plane. These profiles were then analysed by six groups of people: dentists, art students, lay Blacks, lay Whites, lay Chinese and orthodontists. Each participant was asked to choose what he or she considered to be the most attractive profile. The group of profiles could be male or female, 8-years-old, 12-years-old, 16-years-old or adult. The results showed an overall preference for fuller profiles amongst younger patients, and all groups, except the orthodontists, who preferred a more retrusive lip position amongst adult males. The orthodontists liked both sexes to have the same degree of lip protrusion. The author mentioned, in his discussion, that the template photo, on which he based his profile variants, presented with a lower lip that was more prominent than that which would be considered ideal. He suggested that variation between a subject's appreciation of aesthetics and facial harmony might be due to the effect of mass media on the perception of beauty. This study suggests that orthodontists hold different aesthetical values than laypeople and this has implications for treatment planning process, which should be centred around patients concerns.

2.3.1 Perception of Optimal Profile

Mantzikos[79] attempted to define aesthetic soft tissue profile preferences among the Japanese population. The sample included 2,651 randomly selected panelists (mean age, 29.3 $\pm$ 10.1 years) from Japanese cultural and educational backgrounds. The panellists had emigrated from Japan to the United States within the previous 5 years. Five facial profile types were computer-generated by an orthodontist to represent distinct facial types. These profile types were: a class I profile, a bimaxillary retrusive profile, a bimaxillary protrusive profile, a mandibular retrognathic profile and a mandibular prognathic profile. Participants were asked to rank profiles in descending order of attractiveness. Mantzikos found that the class I profile was most preferred and the mandibular prognathism was the least favoured of all profiles within the Japanese study group despite mandibular prognathism being a common profile in Japan. The author suggested that the views of these immigrants, on what is a facially attractive profile, may have already changed over the previous five years due to the influence of the media. He argued that when these Japanese people moved to a culture where there was a wide variety of racial components, their individual

personal views and values about the concept of beauty, were subsequently changed. In addition, Mantzikos asserted that the reason why the class I profile was the first choice was due to the fact that the class I profile seems to simulate the profiles of a variety of different ethnic movie actors.

Chong *et al.*[12] compared the preferences of 251 White and Chinese people, dentists and laypersons, in Australia and China with regard to the aesthetics of Chinese lip position. The assessors were asked to rank eight profile images. The profile images for a dental and skeletal Class I Chinese adult male and female were digitally manipulated for Chinese and White mean values. The lip profile was adjusted with the upper and lower lip at the mean distance from the Ricketts' E-plane and the other profile images were constructed to lie at 0.5, 1.0, and 2.0 standard deviations in front of or behind the E-plane. Chong *et al.* found that there was a significant difference between the judges' preference. The Chinese participants preferred a more retrusive profile and were more likely to rate a protrusive profile as unacceptable, compared with White participants. These findings surprised the authors because the norm amongst the Chinese population is to have more protrusive lips and so it was expected that Chinese participants might find a protrusive profile more acceptable. The fact that the study did not distinguish between native Chinese people living in Australia and new immigrant Chinese people recently moving to Australia was acknowledged by the authors. This might have affected the perception of the aesthetic between the Australian and Chinese groups because new immigrants might share the same aesthetic values as the Chinese group. Therefore, this was considered a limitation of this study. On other hand, the study shows that White participants found the more protrusive profile of Chinese people more acceptable and acknowledged the ethnic variation.

As outlined in the literature review above, the evidence shows a wide range of opinion in terms of how different ethnic groups have different perceptions of aesthetic facial profile. The ethnic group, society or mass media might influence this. The majority of studies in this area have been undertaken in America in multi-cultural populations. These differences often reduce when both ethnicities are submerged in the same society. Few studies involving the perception of dental experts have been

undertaken indicate that orthodontists hold different perceptions regarding ethnic representations of facial beauty than do lay population.

2.4 Clinician's perception of patients' benefit from orthognathic surgery

Previous work has also been carried out to explore the soft tissue landmarks that help orthodontists and maxillofacial surgeons to determine whether or not to recommend orthognathic surgery for patients. Naini *et al.*[81] developed a silhouette study to determine to what extent the degree of chin prominence influenced perceived attractiveness and the decision to recommend orthognathic surgery. A power-point presentation was used to investigate differences in perception of attractiveness between clinicians, patients and lay people. They found that chin retrusion or protrusion, of up to 4 mm, was essentially unnoticeable and that clinicians would recommend surgery for patients with chin protrusion of greater than 6 mm and chin retrusion of greater than 10 mm. There was no statistically significant difference between clinicians and patients or clinicians and laypeople with regards to perceived attractiveness of the silhouettes.

Another study was carried out by Naini *et al*.[82] to assess the influence of mandibular prominence on perceived attractiveness in the orthognathic patient, clinician and layperson. The mandibular prominence of the profile silhouettes was altered in 2 mm increments from -16 mm to 12 mm in relation to ideal Caucasian norms, in order to represent retrusion and protrusion of the mandible, respectively. Using a 7-point Likert scale, clinicians recommended surgery for mandibular protrusions of greater than 5 mm; however, patients and laypeople were more critical and recommended surgery if mandibular prominence was greater than 3 mm. Similar to the study reported above, there was no difference in the aesthetic opinion of the participants. Participants found that the greater the protrusion or the retrusion of the profile, the less attractive the profile and the greater the desire for surgical correction. Based on the results of this study, the authors recommended that, when planning treatment and planning to alter the sagittal prominence of the mandible in an individual, an ideal sagittal position with soft tissue pogonion on or just behind a true vertical line through the subnasale may be used.

Naini *et al.* [83], carried out another study to assess the influence of lower facial profile convexity on perceived attractiveness amongst orthognathic patients, clinicians and laypeople. They altered lower facial profile from the ideal Caucasian norm from 14° to -16° with 2° differences between each image. The participants used a 7-point Likert scale to rate the silhouettes' levels of attractiveness and benefit from surgery. They found that rating decreased for every degree increase in the facial profile convexity. The straight profile was perceived to be most attractive by the participants over the convex and concave profiles. With increased concavity of the profile, the probability of desire for surgery was 69% less for clinicians than for patients. They concluded that patients were more critical than clinicians and laypeople. However, in the studies by Naini *et al.* [81-83] discussed above there was no explanation of how the term "laypeople" was defined or how they selected the sample.

With regard to racial differences, Almeida *et al*.[84] conducted a study to investigate the association between the anteroposterior position of the mandible and the perceived need for orthognathic surgery. Four adults with accepted facial balance vertically and horizontally were selected: one Black male, one Black female, one Caucasian male, and one Caucasian female. Their photographs were altered to produce photos with a straight profile and 6 simulations of mandibular discrepancies, 3 resulting from retrusion and 3 resulting from protrusion from each original face. A total of 28 photographs was produced and each was evaluated by orthodontists, maxillofacial surgeons, artists and laypeople. They found that the participants rated male convex and female concave profiles to be in great need of surgery. In addition, they found that the maxillofacial group was the least tolerant of profile changes and the group containing laypeople was the most tolerant. There was no statistically significant difference in the number of indications for surgery between the photographs of Black and Caucasian individuals.

In order to answer the question of whether a photograph or a silhouette is adequate for evaluating aesthetic profile, Pithon *et al*.[85] carried out a study. In this study, they used a photograph of a Black female with bimaxillary dentoalveolar protrusion. This image was altered to produce a series of seven photos and seven silhouettes with different lip positions by varying the lip position in 2-mm increments from the

Ricketts' E-Plane. A total of 14 images were produced and evaluated by 50 Black and 50 Caucasian laypeople (undergraduate students). They used a 0 to 10 visual analogue scale to rate the level of attractiveness of the images. Both groups of evaluators preferred the less protrusive profile. They found that both methods, photographs and silhouettes, show a good agreement in terms of evaluation of attractiveness.

2.5 Questionnaires and response rate

Not all research questions are suitable for an experimental design. Thus, questionnaires are a useful method to investigate patterns, frequency, and prevalence in a large sample of a given population[86]. They are useful in the medical field to investigate clinicians' and patients' perceptions of treatment. The major concerns would be the achievement of an adequate response rate in order to make the results as representative of the population of interest as possible. There are many recommended strategies in the literature, which may increase response rate. These are related to the questionnaire design with regard to its content, length, type of questions and format of questions.

Questionnaires can be sent web-based, postal or combination of both. There are advantages and disadvantages of each mode of administration. With the advances in the internet speed and spread, web-based questionnaire are found to be a relatively quick method for data collection. An important advantage of using web-based questionnaires is that they can ensure respondent anonymity. If anonymity is assured, participants may feel more comfortable in providing open and honest feedback. This can positively impact on response and completion rates, which are keys to survey success[87]. Moreover, previous studies have found that questionnaires sent by e-mail have fewer incomplete answers compared to the same questionnaires sent by postal mail or fax[88]. However, postal questionnaires have a higher response rate than web-based questionnaires[89]. Each mode therefore has advantages and disadvantages. In order to avoid nonresponse bias, in addition to giving all participants an equal opportunity to choose their preferred mode is suggested. This can be achieved using the mixed mode approach.

Scott *et al.*[90] conducted a randomised controlled trial to investigate the effects and costs of three different modes of questionnaire administration in a national survey of doctors. They compared web-based questionnaires, a simultaneous mixed mode (a paper questionnaire and web-based login details sent together), and a sequential mixed mode (web-based followed by a paper questionnaire with the reminder) in terms of response rate and cost. They found that the sequential mixed mode resulted in a significantly higher response rate than the web-based mode alone, with a slightly higher response rate than the simultaneous mixed mode. In comparison with the web-based mode, the sequential mixed mode was more cost-effective than the simultaneous mixed mode.

The mode of administration is not the only consideration related to a good response rate deficiency. The design and the content of the questionnaire itself are important too. Crawford *et al.*[91] developed standards from theory and practice for the design of the web-based questionnaire to improve response rate. They suggested that a questionnaire should be designed without any background colour or images in order to minimise the upload time of the web page and to prevent the text from becoming difficult to read. Logos should be placed at the top left corner. They recommended using a black colour for text with a size of between 10 and 12 points.

With regards to postal questionnaires, Edward *et al.*[92] suggested strategies to improve the postal questionnaire response rate. They suggested that the use of coloured ink and that first class, stamped return envelopes would increase the response rate. In addition, questionnaires originating from universities were more likely to be returned than those from other sources such as commercial organisations. They recommended contacting participants before sending the questionnaire and suggested that choosing a topic that is of interest to participants.

2.6 Rationale for the study

A systematic electronic search in Medline, EBSCO and Google scholar using search terms attached in Appendix 9.3 identified that the available evidence regarding the benefit from orthognathic surgery is predominantly limited to Caucasians. Therefore, it would be interesting to expand this and further investigation into different racial groups.

In summary, previous studies have concentrated mainly on how soft tissue landmarks influence clinicians' decisions to recommend orthognathic surgery for Caucasians. Whilst this is useful, it is recommended that a set of racial norms for one group should not be applied to people of other. In addition, previous research does not take account of the possible influence of accepted racial norms on clinicians' judgments. Authors suggest that more work needs to be done in this area[93], particularly to investigate the effect of patients' race on clinical decision-making. Also relevant to the topic is whether the personal values and attitudes of clinicians regarding facial attractiveness influence clinical judgments in terms of whether orthognathic surgery is needed or not.

A further gap in the literature has been identified in this area, which is to assess if maxillary position influences clinicians' decisions in terms of whether to recommend orthognathic surgery or not. Literature suggests that it would be valuable to identify whether the race of the patient affected this decision especially as the average Chinese profile is maxillary retrusive with a tendency towards a class III skeletal pattern. With this in mind this study has been designed to investigate this area by comparing two racial groups (Caucasian and Chinese), using silhouettes and manipulating the silhouettes to produce a retrusive maxillary position, or prognathic mandibular position leading to a class III skeletal relationship.

3 Aims and Objectives

3.1 Research Question

Does the racial background of the patient influence clinicians' perception of the benefit from orthognathic surgery in patients presenting with class III skeletal discrepancies?

3.2 Study Aim

To investigate the impact of patients' race on influencing whether clinicians perceive that a patient with class III skeletal bases would benefit from orthognathic surgery.

3.3 Study Objectives

1. To compare clinicians' rating of the key soft-tissue profile values (A point and B point) that might indicate the benefit from orthognathic surgical treatment, in patients with a class III skeletal base, of Caucasian and Chinese origin.
2. To identify which profile clinicians rate as the most attractive for:
    a. Caucasian patients;
    b. Chinese patients and
    c. whether the Caucasian profile is considered more or less attractive than the Chinese.
3. To identify clinician-related factors that might influence decisions including clinicians':
    a. years of qualification;
    b. gender;
    c. ethnicity;
    d. specialty (orthodontics/oral and maxillofacial surgery);
    e. location of work and
    f. the number of orthognathic patients treated each year.
4. To investigate the role of clinicians' personal values with regard to facial attractiveness in influencing their clinician decision making in terms of the perceived benefit from orthognathic surgery.

4 Methods

4.1 Sampling Frame

A cross-sectional survey was conducted from April 2015 to July 2015. The questionnaire was distributed to all consultant orthodontists and maxillofacial surgeons in the United Kingdom using the mailing lists of the British Orthodontic Society (BOS) and British Association of Oral and Maxillofacial Surgeons (BAOMS). There was a total of 315 consultant orthodontists registered with the BOS. There were 98 consultants in Oral and Maxillofacial surgery registered with the Deformity Sub-Specialty Interest Group of the BAOMS on March 2015. The deformity group include oral and maxillofacial surgeons who are interested in craniofacial deformity and orthognathic surgery. This group consists of 30% of oral and maxillofacial surgeons who are members of the BAOMS.

4.1.1 Sample Size Calculation

The sample size calculation was carried out based on the pilot data from 18 participants (3 oral and maxillofacial surgeons, 3 orthodontic consultants, 2 senior orthodontic registrars and 10 orthodontic registrars). From this pilot, it was estimated that the intra-cluster correlation coefficient for ratings of benefit for surgery would be 0.06. The study was powered to detect a difference in the ratings for benefit from surgery between the Caucasian and Chinese silhouettes. A sample size of 158 was identified as allowing the detection of a difference of 6% between the average overall ratings of the Caucasian and Chinese silhouettes, adjusted for the clustering of ratings within raters, with 80% power, and $\alpha = 0.05$. With a minimum target sample size of 158, the questionnaires were sent to 413 participants (315 consultant orthodontists and 98 consultant oral and maxillofacial surgeons) to allow for a 38% response rate for the survey.

4.1.2 Ethical Approval

Ethical approval was obtained from the Institute of Learning and Teaching Ethics Review Group at the University of Liverpool (ref no. 201502189) attached in Appendix 9.4. After ethical approval was obtained, the administrative departments of the BOS and BAOMS were contacted. Audit committee approval was then obtained

from the research lead at the BOS and BAOMS to distribute the questionnaires and start data collection.

4.2 Questionnaire

4.2.1 Mode of Administration of Questionnaire

A sequential, mixed mode questionnaire format was used for the consultant orthodontic group. This mode starts with an initial attempt to conduct the survey through web-based administration, with a mailed follow-up for non-responders. A series of three reminders was sent out. The first and second email reminders were sent 6 weeks and 10 weeks after the web-based questionnaire distribution respectively.

The postal invitation was sent 2 weeks after the start of the web- based questionnaire. Then, a postal reminder which included a paper version of the questionnaire, together with a stamped, self-addressed envelope and an option to fill the questionnaire in web-based was sent out 8 weeks later. No incentives were offered. The data collection process is illustrated in figures 4.1 and 4.2.

The BAOMS Office does not circulate questionnaire s to members via hard copy mailings. The facility they provide for approved questionnaires involved email circulation to the required group. Confidentiality of the members' details did not allow for direct mailing to the members. Therefore, only web-based questionnaire could be used for the oral and maxillofacial surgeons group. Two reminders emails were sent by the BAOMS office to Deformity Sub-Specialty Interest Group at 2 weeks and 6 weeks later.

Figure 4.1: The diagram compares the two different modes of administration used to distribute the questionnaire to BOS and BAOMS members

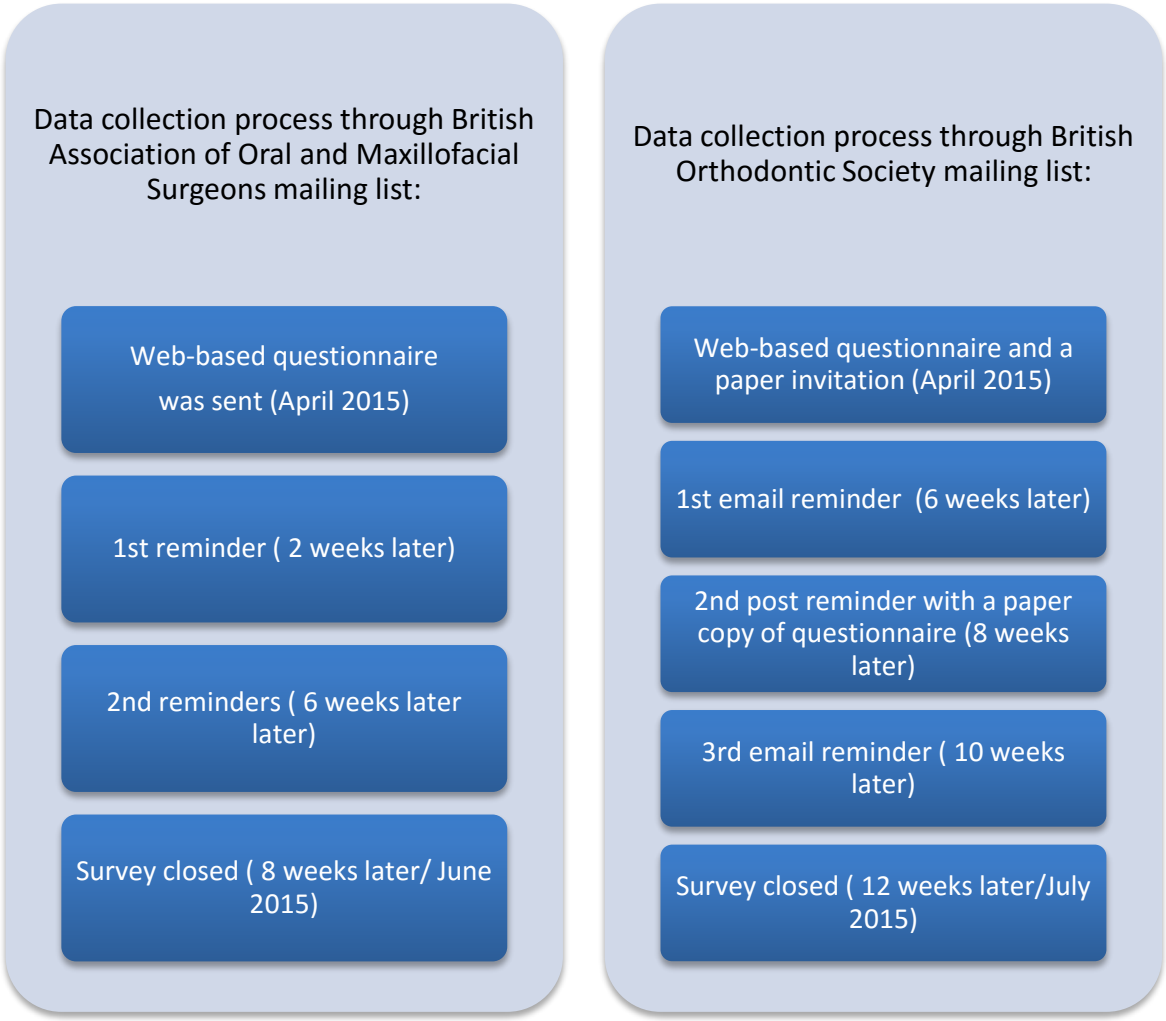
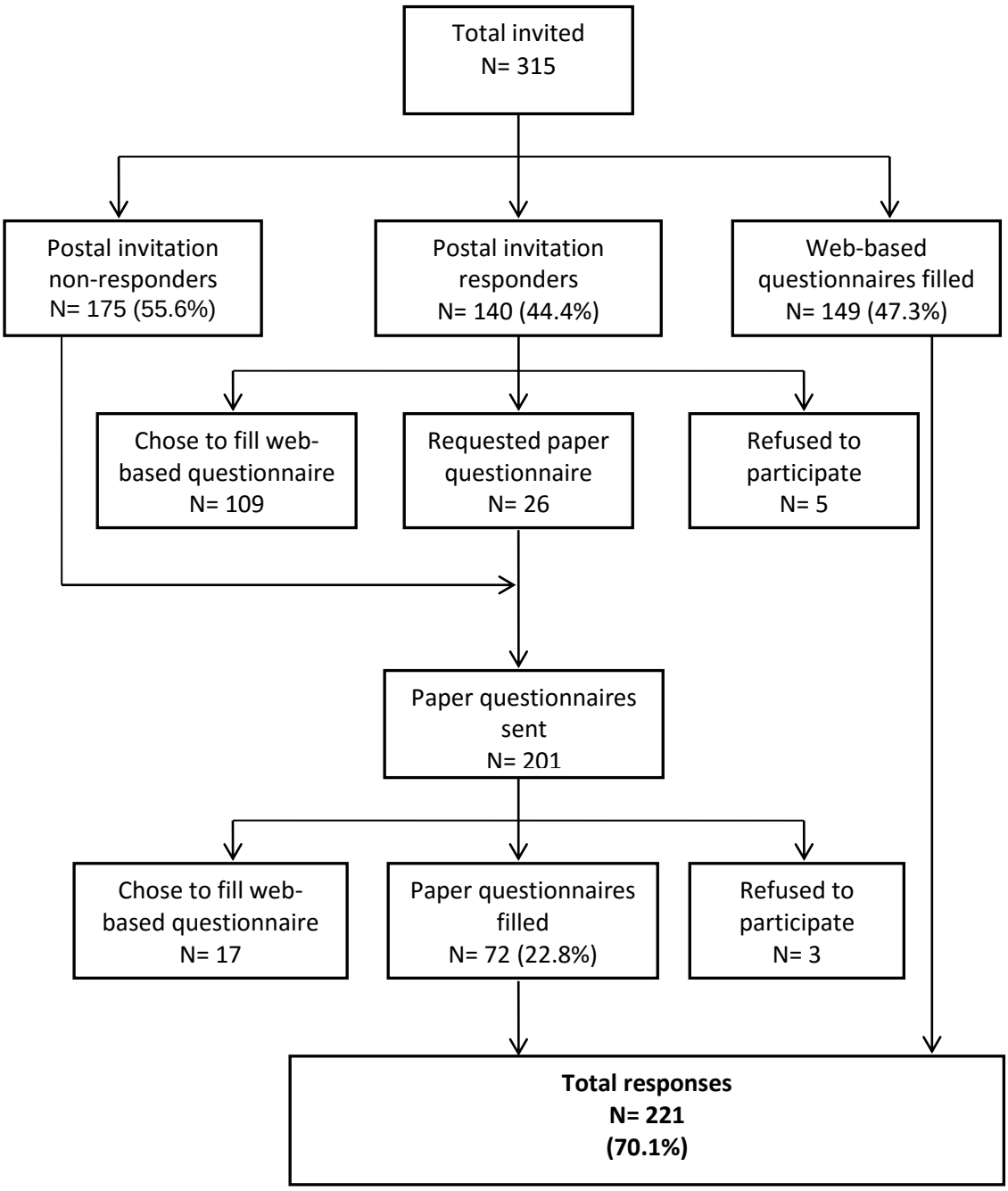


Figure 4.2: Participants flow diagram for consultant orthodontists group



4.2.2 Invitation Letter

The invitation letter, at the start of the survey, included information about the study title and the purposes of the study and reassured the participants about the anonymity of the data. The participants were asked to spend no more than 30 seconds looking at each silhouette and then answer the following questions: “Do you

think that a patient, presenting with this profile, would benefit from orthognathic surgery?" and "How do you rate the level of attractiveness of this profile?"

The chief investigator (NF) signed the invitation letter. A copy of the web-based letter is attached as Appendix 9.5. At the end of the letter, there was a space for potential participants either to consent or refuse to consent in the remainder of the survey. In addition, a paper version of the invitation letter, concurrent with the web-based questionnaire, was sent by post to all participants with an option to request a paper copy of the questionnaire (Appendix 9.6). The questionnaire was anonymous but a code was used to allow us to follow up those who have not responded. The codes were be kept by the BOS secretaries for follow up purposes only. A reminder paper letter with the paper questionnaire was sent to every consultant orthodontists who requested a paper copy or did not respond to the invitation letter (Appendix 9.7).

4.2.3 Content of Questionnaire

The questionnaire was divided into four sections (Appendix 9.12):

- Section 1 and 2 collected demographic data on the participant, including age, gender, ethnic origin, current occupation, place of work, years of qualification and the number of orthognathic patients they treat every year. In addition, participants were asked how important they think it is to have attractive facial features.
- Section 3 included an ideal patient profile silhouette and 10 manipulated silhouettes of a 16-year-old Caucasian female patient and two duplicate silhouettes, to check the intra-examiner reliability, giving a total of 13 silhouettes. Each silhouette was followed by two questions; the first question was "Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?" and the second was "How do you rate the level of attractiveness of the profile?"
- Section 4 included an ideal patient silhouette and 10 manipulated silhouettes of a 16-year-old Chinese female patient and two duplicate silhouettes, to check the intra-examiner reliability, giving a total of 13 silhouettes. These silhouettes were followed by two questions; the first question was "Do you think that a patient, presenting with this profile, would benefit from orthognathic

surgery?" and the second was "How do you rate the level of attractiveness of the profile?"

4.2.4 Design of the Questionnaire

Survey Monkey®, accessible at www.surveymonkey.com, was used to form the outline and design for the web-based questionnaire. The design of the web-based questionnaire followed design standards suggested by Crawford *et al*.[91] that were discussed in section 2.5. The content of the wed-based and paper questionnaires were the same; however, the format for the paper-based version was developed using Microsoft Word and followed strategies suggested by Edward *et al.*[92] to improve the postal questionnaire response rate. These strategies were discussed in section 2.5.

Data tabulation reliability

Transfer of paper response to data collection tables on a computer could have lead to tabulation errors. Therefore, to minimise error and ensure that data entered onto the computer were accurate, data entered were checked on three separate occasions. No more than 6 paper questionnaires were transferred to computer per sitting to avoid errors due to fatigue. In addition, 10% of paper responses were selected randomly and checked by research supervisor (N.F.) to assure correct data tabulation.

4.2.5 Silhouettes

The decision to use a silhouette fabricated from Liverpool Dental Hospital patients' photographs was made to make the analysis as representative of a real-life situation as possible. The patients' profile photographs were taken with the patient in natural head position by asking the patient to look into her own reflection in a mirror, which has been shown to be the most reproducible[94]. Silhouette profile images were used to eliminate the influence of skin colour, hair texture, and other characteristics that might bias participants' judgment. A ruler was placed at the top right corner to the potential effect of image magnification or size reduction on the clinician's perception.

The silhouettes' manipulation did not extend beyond 10 mm because this is the limit for surgical advancement of maxilla proposed by Proffit *et al.*[27] there was no previous studies that looked at the clinicians' decision for recommending surgery for

patients' with maxillary deficiency. Therefore this study was based on Proffit *et al.*[27] surgical limit for advancement of the maxilla. On the other hand, the surgical limit suggested by Proffit *et al.* [27] for mandibular setback was 24 mm. However, previous research has found that clinicians recommended surgery for mandibular protrusions of greater than 5 mm[41]. Therefore, for this study the silhouettes' manipulation for the mandible was 10 mm to have equal amount of manipulation for each jaw to allow comparison.

Profile Construction

The silhouettes were constructed from profile photographs of patients attending Liverpool University Dental Hospital.

Those whose images were considered for the study:

- had consented to have their photographs used for research purposes;
- were Caucasian or Chinese with average vertical proportions based on Farkas *et al.'s* [64-67] soft tissue norms.

Two profile photographs, representing Caucasian and Chinese norms, were selected of patients who were the same age (16 years old) and gender (female). These photographs were converted to silhouettes using Adobe Photoshop®. Then, the profile measurements were made on a life size version of the silhouette using extra fine pen to locate the points and measure the linear spaces and angles using an orthodontic ruler as attached in Appendices 9.8 and 9.9.

The maxillary position of the selected normal profile silhouettes was manipulated posteriorly from the norm, in 2 mm increments, up to 10 mm. The mandibular position, of the selected normal profile silhouettes, was manipulated anteriorly from the norm, in 2 mm increments up to 10 mm. Thirteen silhouettes were constructed per racial group i.e:

- The norm, which is 0 mm from the true vertical line [68]
- 2 mm, 4 mm, 6 mm, 8 mm to 10 mm posteriorly from the norm of the maxilla (Figure 4.3 and 4.4) and
- 2 mm, 4 mm, 6 mm, 8 mm to 10 mm anteriorly from the norm of the mandible (Figure 4.5 and 4.6)
- one duplicate for each jaw per race

Therefore, a total of 26 silhouettes were constructed. The duplicate silhouettes were placed within the test batch of profiles, to assess the intra-rater reliability. Each silhouette was assigned double letters listed in appendix 9.10.

Figure 4.3 Illustration of how the maxilla moved posteriorly from the norm in Caucasian Silhouette by 2 mm (AS), 4 mm (MF), 6 mm (LR), 8 mm (MH), 10 mm (SM)

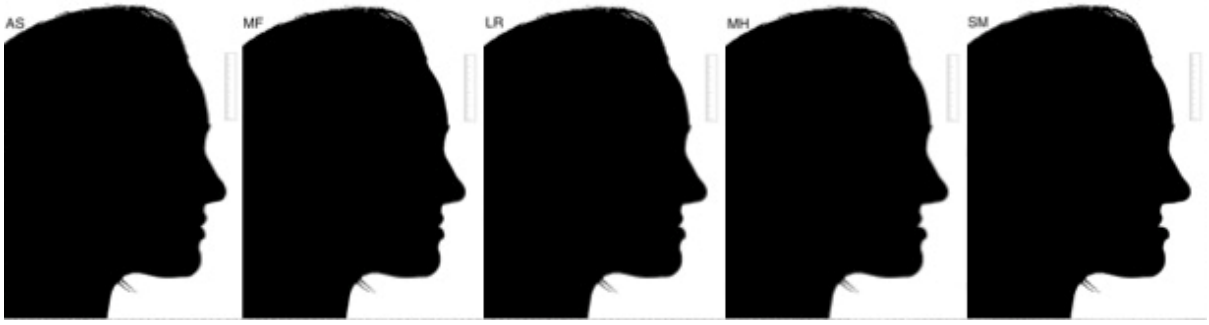


Figure 4.4 Illustration of how the maxilla moved posteriorly from the norm in Chinese Silhouette by 2 mm (SR), 4 mm (GR), 6 mm (MT), 8 mm (SH), 10 mm (SC)

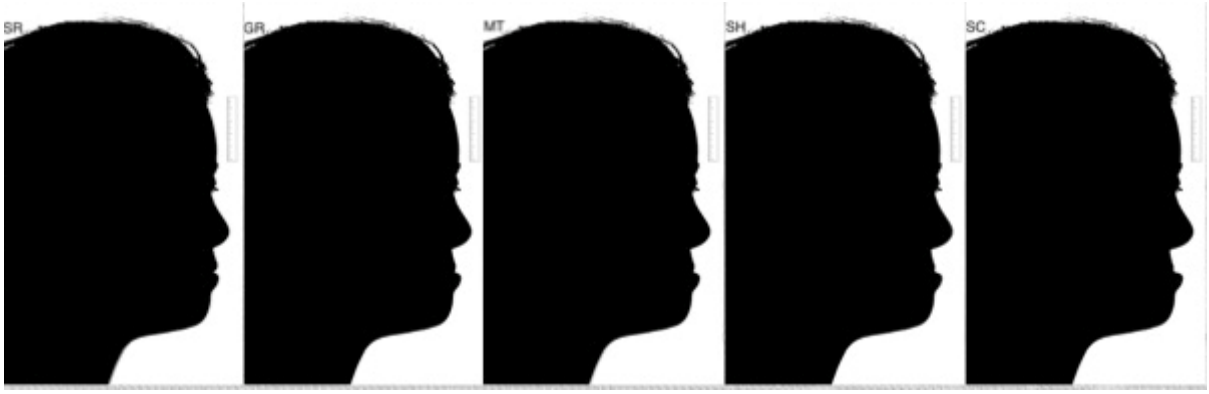


Figure 4.5 Illustration of how the mandible moved anteriorly from the norm in Caucasian Silhouette by 2 mm (AM), 4 mm (EW), 6 mm (RS), 8 mm (MA), 10 mm (NS)

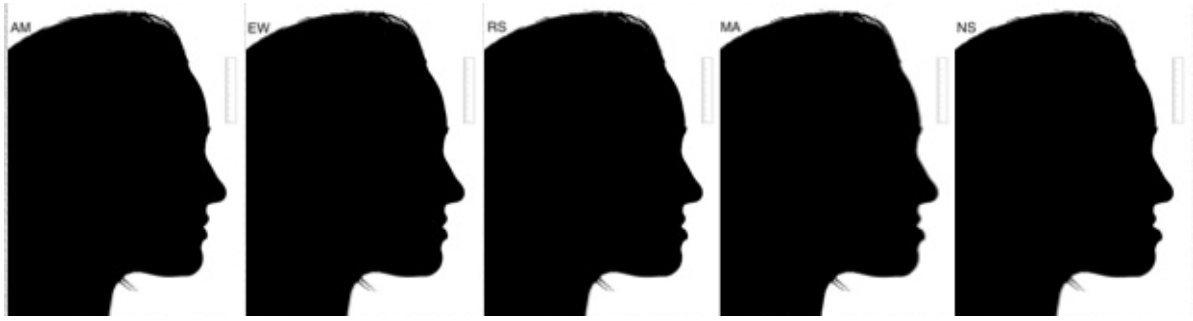
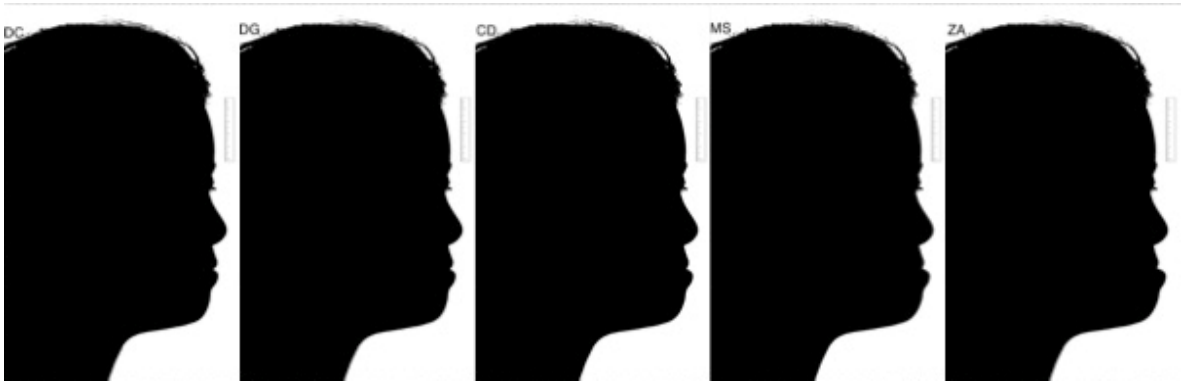


Figure 4.6 Illustration of how the mandible moved anteriorly from the norm in Chinese Silhouette by 2 mm (DC), 4 mm (DG), 6 mm (CD), 8 mm (MS), 10 mm (ZA)



To choose the duplicated silhouette letters where inputted into a website called random name picker[95] and the double letters that were picked for:

- Caucasian manipulated maxillary position were MH
- Caucasian manipulated mandibular position were RS
- Chinese manipulated maxillary position were GR
- Chinese manipulated mandibular position were ZA

Then the double letters were inputted into a website called List randomizer[96] to arrange them randomly. The random order that was generated for Caucasian and Chinese silhouettes is listed in appendix 9.11.

4.2.6 Pilot study

A pilot study was conducted at Liverpool University Dental Hospital to evaluate the questionnaire internal validity and calculate the sample size for this study. The questionnaire content was piloted on 3 consultant orthodontists, 3 consultant oral and maxillofacial surgeons, 2 senior and 10 orthodontic registrars at Liverpool University Dental Hospital. E-mail and paper copies of the questionnaire were sent to ask them to critique the questionnaire's presentation and clarity. All suggestions made by the participants of the pilot study were considered.

The time taken to complete the questionnaire was recorded and it was decided it is reasonable to spend 30 seconds per silhouettes. One question was discarded because all participants suggested that it is unnecessary. The question was "How do you rate you own facial attractiveness?" They thought that this question would not add to our understanding because clinician would properly give unreliable

answers. One question was re-worded because it may not be answered as expected. The question was ""Do you think this patient based on this profile view needs surgery?". Consultants' comment on that question was they would never think that any patient would need surgery however, patients may benefit from surgery. Therefore, the question was rephrased to "Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?". A caption was added beneath every silhouette to describe the race of the silhouette.

4.3 Data Analysis

4.3.1 Analysis Strategy

All data collected from consultant orthodontists' and oral and maxillofacial surgeons' questionnaires were analysed using SPSS 22.0 (SPSS Inc., Chicago, Illinois, USA and SAS Version 9.3 (SAS Institute Inc., Cary, North Carolina, USA). A p-value of less than 0.05 was considered a statistically significant difference. Descriptive statistics were used to analyse the demographic data of the participants e.g. mean and 95% confidence intervals or median and interquartile range, as appropriate.

Mixed linear and logistic regressions analyses were used for data analyses as appropriate, with silhouette ratings clustered within clinicians groups, and taking into account the effects of racial group, amount of maxillary/mandibular manipulation and clinician effects such as specialty, gender and ethnicity to be modelled.

This study would compare the clinicians' perception of the benefit from orthognathic surgery in patients of two racial backgrounds (Caucasian and Chinese) who presented with a class III skeletal discrepancy. Therefore, comparisons would be as follows:

- Orthodontists' perception for the benefit from surgery for Caucasian skeletal class III profiles versus Chinese skeletal class III profiles.
- Maxillofacial surgeons' perception for the benefit from surgery for Caucasian skeletal class III profiles versus Chinese skeletal class III profiles.
- Orthodontists' perception for the benefit from surgery for Caucasian skeletal class III profiles versus maxillofacial surgeons' perception for the

benefit from surgery for Caucasian skeletal class III profiles.

- Orthodontists' perception for the benefit from surgery for Chinese skeletal class III profiles versus maxillofacial surgeons' perception for the benefit from surgery for Chinese skeletal class III profiles.
- If no difference between the perception for the benefit from surgery between orthodontists' and maxillofacial surgeons was found, then the results would be combined to compare the all the clinicians' perception for the benefit from surgery for Caucasian skeletal class III profiles versus Chinese skeletal class III profiles.

4.3.2 Study Measures

The outcome of this study was measured using a dichotomous scale and a Likert scale. Participants were asked to assess the benefit from surgery on a dichotomous scale: 'Yes' or 'No'. In addition, they were asked to rate the level of attractiveness on a 7 point Likert scale:

1. Extremely unattractive
2. Very unattractive
3. Slightly unattractive
4. Neither attractive nor unattractive
5. Slightly attractive
6. Very attractive
7. Extremely attractive

4.4 Data Handling

There was no direct contact with participants' details because the data collection process was through BOS and BAOMS secretaries. All anonymised data was stored on a password-protected computer. All study data was stored and archived in line with the Medicines for Human Use Amended Regulations 2006 as defined in the Joint Clinical Trials Office Archiving SOP.

5 Results

5.1 Response rate

The overall response rate for this study was 273 (66.1%). Out of 315 consultant orthodontists, 221 (70.1%) questionnaires were collected. With regard to mode of data collection, 149 consultant orthodontists completed the questionnaire web-based and 72 completed a paper version of the questionnaire. The completion rate of web-based questionnaires was 94% and the paper copies was 72%. Eight consultant orthodontists refused to participate in the study. Four of them returned blank questionnaires with a note that they were retired and the other four did not specify a reason. The data collection process was illustrated in figure 4.2. With regards to oral and maxillofacial group, out of 98 consultant oral and maxillofacial surgeons, 52 (53%) completed the web-based questionnaires.

5.1.1 Relationship between data collection mode and responders' demographic characteristics (orthodontists only)

The percentage of male orthodontists responders was slightly higher using the web-based mode and this was not statistically significant. The percentage of female orthodontists responders was slightly higher using the paper mode and this was not statistically significant (p=0.10). The mean age of responders was almost the same in web-based and paper mode of 47.6 years and 47.1 years respectively (Table 5.1)

Table 5.1: Relationship between data collection mode and responders' demographic characteristics (orthodontists only)

Variables	P- value	Web-based mode			Paper mode		
		Mean (S.D)	**N**	**Percentage (%)**	**Mean (S.D)**	**N**	**Percentage (%)**
Gender	P= 0.10*						
Males			84	56.4		31	44.2
Females			65	43.6		39	55.7
Age (yrs)	P= 0.75**	47.6 (11.0)	113		47.1 (8.9)	67	

*Chi-square test was used

**T-test was used

5.2 Reliability of measures

Intra-rater reliability

The intra-rater reliability for the raters was found to be Kappa = 0.63 with 95% CI (0.568, 0.696). This is considered substantial agreement[97]. In addition, McNemar test was used to assess the participant reliability and it is shown in table 5.2. There was a statistically significant difference in the intra-rater ratings for silhouettes RS and GR (Table 5.2). Silhouette RS represented the Caucasian silhouette with 6 mm anterior mandibular manipulation and silhouette GR represented the Chinese silhouette with 4 mm posterior maxillary manipulation. In addition, these data indicate that there was not much variation in the intra-rater ratings for silhouettes MH and ZA. Silhouette MH represented the Caucasian silhouette with 8 mm maxillary manipulation and silhouette ZA represented the Chinese silhouette with 10 mm mandibular manipulation (Table 5.2).

Table 5.2: The difference in perceptions of the participants for benefit from surgery between the original silhouette and the duplicate

Silhouette Race	Degree of Manipulation	Number of clinicians who rated the original Silhouette	Number of clinicians who rated the duplicate Silhouette	McNemar's Test P-value
Caucasian				
Silhouette RS	Mandible 6 mm	113	140	<0.0001*
Silhouette MH	Maxilla 8 mm	248	244	<0.219
Chinese				
Silhouette GR	Maxilla 4 mm	167	206	<0.0001*
Silhouette ZA	Mandible 10 mm	239	240	<0.727

* Indicate statistical significance

Data tabulation reliability

Research supervisor (N.F.) randomly selected and checked 10% of paper responses to assure correct data tabulation. Seven questionnaires were selected and the inter examiner reliability found to be 100%. This adds to the reliability of the findings of this study.

5.3 Descriptive data

This section describes the demographic characteristics of the responders, and the prevalence of their responses to the main variables of interest.

5.3.1 Age and gender

The mean age of the consultant orthodontists was 47.4 years (standard deviation (SD) 9.2; 95% confidence Interval (CI) 46.2, 48.6) and 52.5% of the consultant orthodontists were male (Figure 5.1). The mean age for the consultant oral and maxillofacial surgeons was 51.7 years (SD 6.05; CI 50.1, 53.4) and 88.5% were males (Figure, 5.2).

Figure 5.1: Mean age of consultant orthodontists is 47.4 years with SD 9.2.

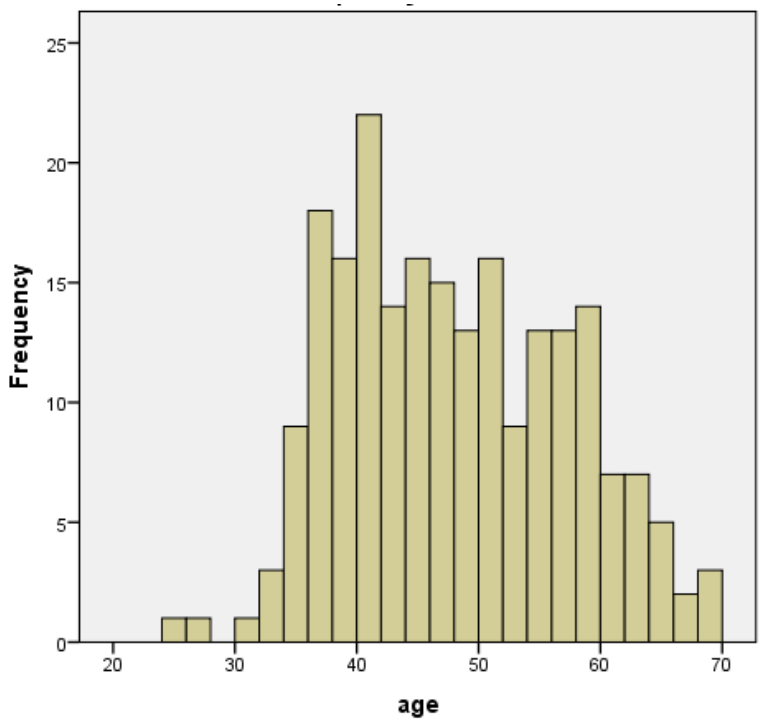
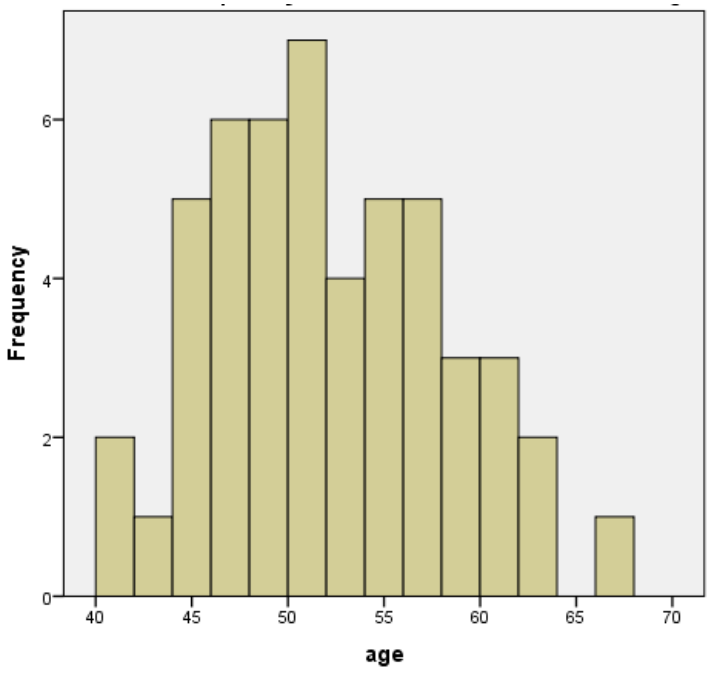


Figure 5.2: Mean age of oral and maxillofacial surgeons is 51.7 years with SD 6.0



5.3.2 Ethnicity

Three-quarter (75.5%) of consultant orthodontists who answered the questionnaire were White British, 10% were Asian Indian, 5.9% were White Irish, and 1% were of Asian Chinese background. There were 0.9% Asian Pakistani, and 0.4% Black African. Other ethnic groups e.g. Arabian, Iranian, another White ethnic group and mixed White compromised 5.3% of the orthodontists (Table 5.3). The vast majority of the oral and maxillofacial surgeons were White British (80.8%). The rest of participants were White Irish (3.8%), Asian Indians (9.7%), Asian Pakistanis (1.9%) and Asian Chinese (1.9%). One participant (1.9%) was from other White background (Table 5.3).

Table 5.3: Number and percentage of participants based on their ethnic background

Ethnic group	Consultant Orthodontists		Consultant oral and maxillofacial surgeons		Total
	No.	%	No.	%	No.
Asian Chinese	3	1	1	1.9	4
Asian Indian	23	10	5	9.7	28
Asian Pakistani	2	0.9	1	1.9	3
Black African	1	0.4	0	0	1
White British	167	75.5	42	80.8	209
White Irish	13	5.9	2	3.8	15
Others	12	5.3	1	1.9	13
Total	221	100	52	100	273

5.3.3 Importance of facial profile

Nearly half (49.3%) of consultant orthodontists reported they thought was very important to have an attractive facial profile. More than one-third (39%) reported they thought was slightly important to have an attractive facial appearance. Smaller percentage (8.3%) thought it is extremely important and (3.4%) thought it is neither important nor unimportant to have an attractive facial profile. Out of 52 oral and maxillofacial surgeons, half (51.1%) think it is slightly important to have an attractive facial appearance. On the other hand, more than one-third (37.8%) thinks it is very important to have an attractive facial appearance. The rest of the participants (11.1%) think it is extremely important to have an attractive facial profile (Table 5.4).

Table 5.4: How important does the consultant orthodontists and oral maxillofacial surgeons think it is to have an attractive facial profile?

Rating of importance of facial attractiveness	Consultant Orthodontists		Consultant oral and maxillofacial surgeons	
	No.	%	No.	%
Extremely important	18	8.3	6	11.1
Very Important	107	49.3	19	37.8
Slightly important	85	39	27	51.1
Neither important nor unimportant	7	3.4	0	0
Total	217	100	52	100

5.3.4 UK region of participants

Data were gathered nationally with responses obtained from both consultant orthodontists and consultant oral and maxillofacial surgeons from a range of areas (Figure 5.3 and Figure 5.4). Out of 221 consultant orthodontists who answered the questionnaire, 14.0% were from London and 11.8% were from Scotland. The least represented areas were South West Thames and Republic of Ireland by 0.9%. Out of 52 oral and maxillofacial surgeons, 9.6% were from Scotland and 9.6% South East region. The least represented areas were Oxford group, Northern Ireland and North Wales by 1.9% for each.

Figure 5.3: The distribution of the consultant orthodontists in UK (the regional distribution is based on BOS regional audit groups)

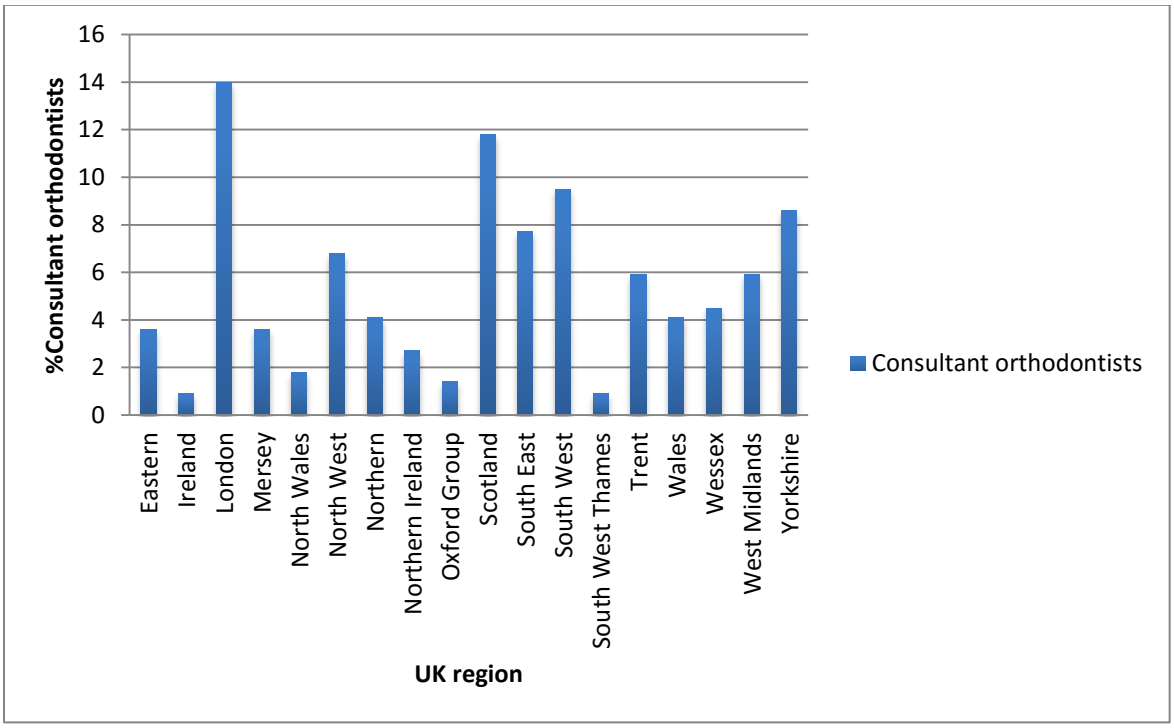
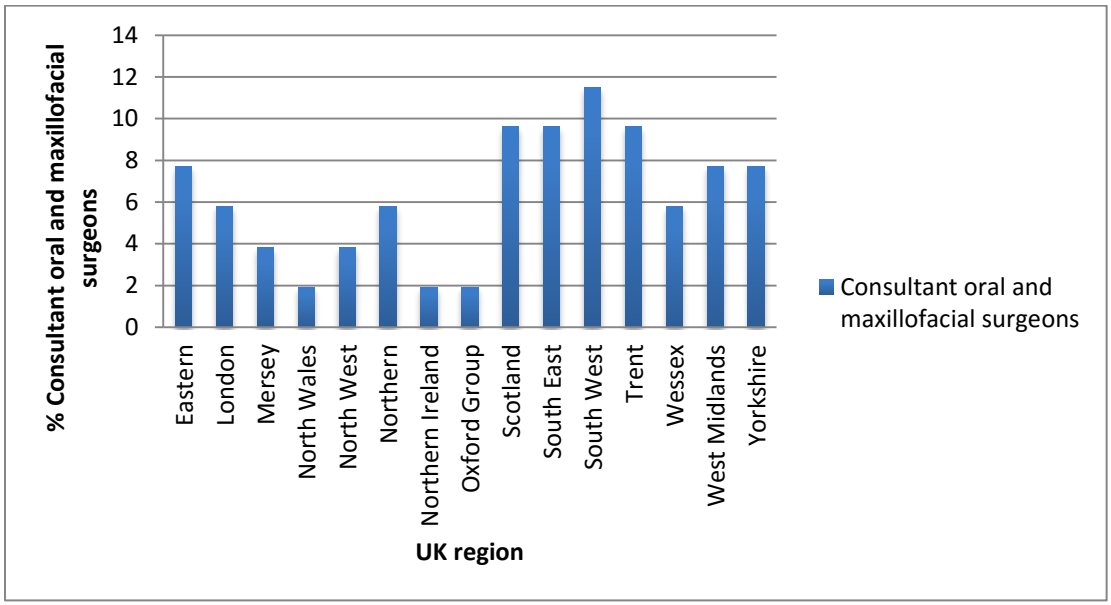


Figure 5.4: The distribution of the consultant oral and maxillofacial surgeons in UK (the regional distribution is based on BOS regional audit groups)



5.3.5 Number of years served as a consultant

Out of 221 consultant orthodontists who completed the questionnaire, the number of years in service as a consultant ranged from 1 year to 40 years (Figure 5.5), with the mean time being 12.8 years (SD 8.7; 95% CI 11.6, 13.9). On the other hand, for the oral and maxillofacial surgeon group, the number of years in service as a consultant ranged from one year to 28 years (Figure 5.6), with the mean time being 12.6 years (SD 6.9; 95% CI 10.65, 14.55).

Figure 5.5: Number of years in service as a consultant for orthodontists ranged from one year to 40 years, with the mean time being 12.8 years.

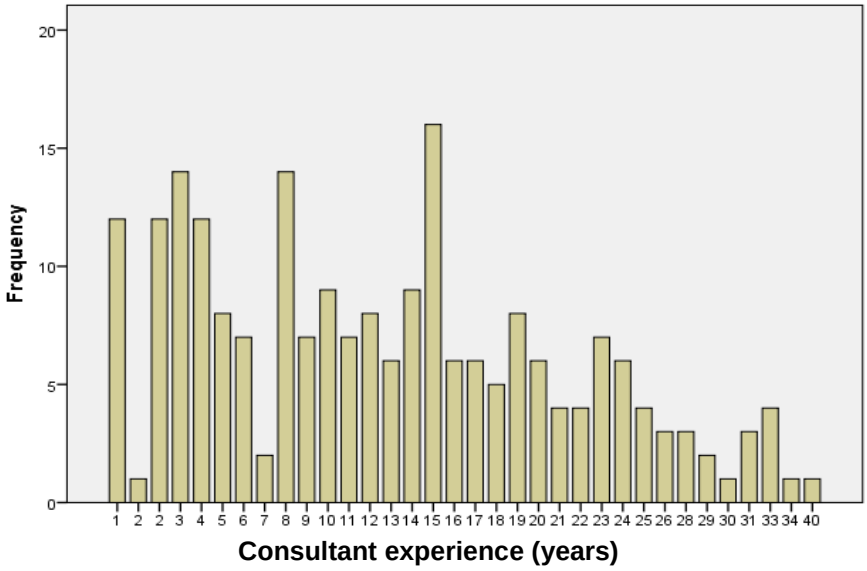
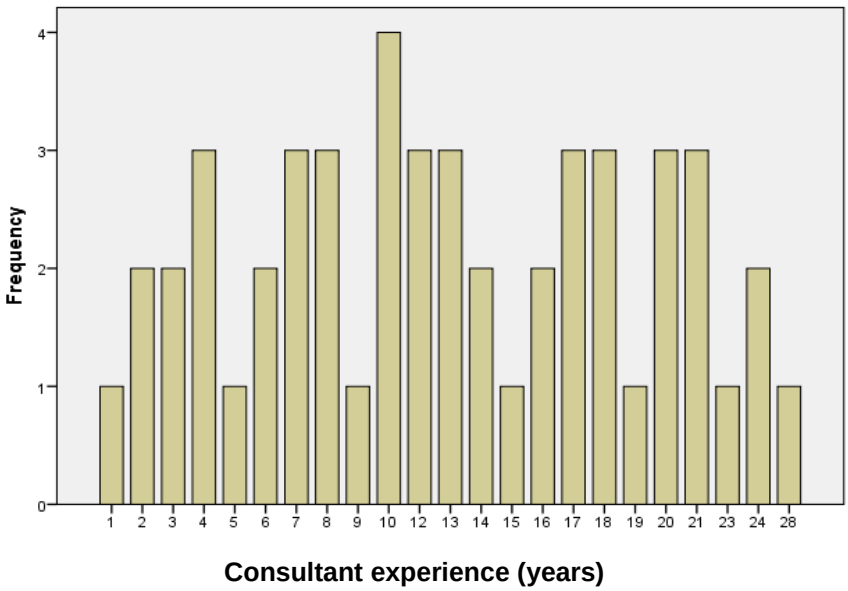


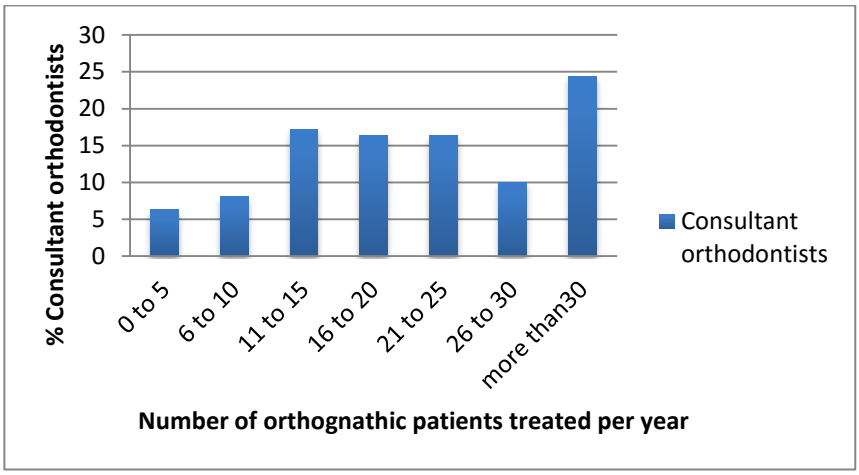
Figure 5.6: Number of years in service as a consultant for oral and maxillofacial surgeons ranged from one year to 28 years, with the mean time being 12.6 years.



5.3.6 Number of orthognathic patients treated by participants

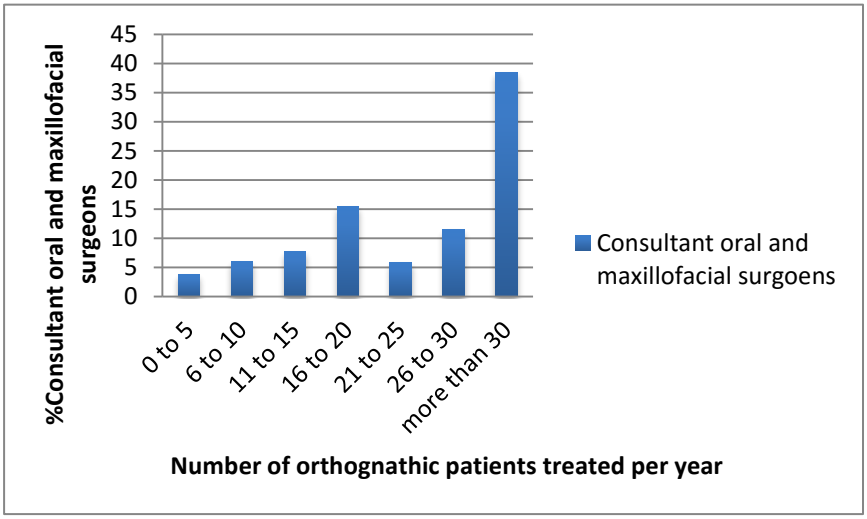
The highest percentage (24.4%) of consultant orthodontists treats more than 30 orthognathic patients on average annually. Approximately 17.2% of the consultant orthodontists treat 11 to 15 orthognathic patients on average per year. Around 16.3% of them treat 16 to 20 and 21 to 25 orthognathic patients per year (Figure, 5.7).

Figure 5.7: The number of orthognathic patients treated by the consultant orthodontists annually.



Of 52 oral and maxillofacial surgeons, approximately more than one-third (38%) treats more than 30 orthognathic patients on average per year, (15.4%) treat 16 to 20 orthognathic patients, and (11.5%) treat 26 to 30 orthognathic patients per year. A smaller percentage (7.7 %) and (5.8%) treat 11 to 15 and 21 to 25 orthognathic patients on average per year, respectively (Figure, 5.8).

Figure 5.8: The number of orthognathic patients treated by the consultant oral and maxillofacial surgeons annually.



5.4 Perceived benefit from surgery

5.4.1 Consultant orthodontists versus consultant oral and maxillofacial surgeons

From univariate mixed logistic regression (Table 5.9), there was no statistically significant difference between the perception of the benefit from orthognathic surgery between consultant orthodontists and consultant oral and maxillofacial surgeons (odds ratio=1.11; p=0.176; 95% CI 0.96, 1.28). Therefore, the results were combined to compare the perception of all the clinicians about the benefit from surgery for Caucasian skeletal class III profiles versus Chinese skeletal class III profiles.

5.4.2 Caucasian silhouettes

Each silhouette was given a double letter to be identified and referred to in the data analysis (Appendix 9.10). In this study, there was 22 silhouette fabricated for Caucasian and Chinese with maxillary manipulation or mandibular manipulation. One duplicate for each jaw per race was selected randomly and a total of four duplicate silhouettes were placed in the questionnaire. Therefore, the participants rated a total of 26 silhouettes.

The highest rated (99.6%) for the Caucasian silhouettes and thereby most perceived benefit for surgery silhouette was silhouette NS and SM, representing the most severe degrees of maxillary retrusion and mandibular protrusion (Table 5.5). The lowest rated silhouettes (FS, AS and AM) demonstrate the ideal facial profile, very minor degrees of maxillary retrusion and mandibular protrusion, respectively.

Table 5.5: Participants' rating for the Caucasian silhouettes when asked if they think that a patient, presenting with this profile, would benefit from orthognathic surgery.

Silhouette code	Manipulation (mm)	Total	Agree		Disagree	
			N	**Percentage (%)**	**N**	**Percentage (%)**
FS	0	249	4	1.6	245	98.4
	Mandible manipulated anteriorly (mm)					
AM	2	246	0	0	246	100
EW	4	250	10	4	240	96
RS	6	250	113	45.2	137	54.8
MA	8	249	236	94.8	13	5.2
NS	10	257	256	99.6	1	0.4
	Maxilla manipulated posteriorly (mm)					
AS	2	250	4	1.6	246	98.4
MF	4	249	16	6.4	233	93.6
LR	6	260	234	90.0	26	10.0
MH	8	252	248	98.4	4	1.6
SM	10	253	252	99.6	1	0.4

5.4.3 Chinese silhouettes

The highest rated (98.4%) for the Chinese silhouettes and thereby most perceived benefit for surgery silhouette was silhouette SC, representing the most severe degrees of maxillary retrusion (Table 5.5). Other highly rated (97.6%) for perceived benefit for surgery silhouette was silhouette ZA representing severe mandibular protrusion. The lowest rated silhouettes (FM, DC and SR) demonstrate the ideal facial profile, very minor degrees of mandibular protrusion and maxillary retrusion, respectively (Table 5.6).

Table 5.6: Participants' rating for the Chinese silhouettes when asked if they think that a patient, presenting with this profile, would benefit from orthognathic surgery.

Silhouette code	Manipulation (mm)	Total	Agree		Disagree	
			N	**Percentage (%)**	**N**	**Percentage (%)**
FM	0	244	4	1.6	240	98.4
	Mandible manipulated anteriorly (mm)					
DC	2	242	9	3.7	233	96.3
DG	4	241	51	21.2	190	78.8
CD	6	244	153	62.7	91	37.3
MS	8	245	213	86.9	32	13.1
ZA	10	247	239	96.8	8	3.2
	Maxilla manipulated posteriorly (mm)					
SR	2	243	17	7.0	226	93.0
GR	4	241	167	69.3	74	30.7
MT	6	242	171	70.7	71	29.3
SH	8	243	225	92.6	18	7.4
SC	10	247	243	98.4	4	1.6

5.4.4 Caucasian versus Chinese silhouettes ratings for benefit from surgery

The participants' ratings for benefit from surgery were different for Caucasian and Chinese silhouettes. This shows that Chinese silhouettes are rated more in term of benefit from surgery than Caucasian silhouettes with the same degree of manipulation. For the maxillary manipulation of 4 mm, more than two-thirds of participants thought that Chinese silhouette would benefit from surgery compared to only 6.4% of the participants thought that Caucasian silhouette would benefit from surgery. For the mandibular manipulation of 4 mm, almost one-quarter of the participants thought that Chinese silhouette would benefit from surgery compared to only 4% of the participants thought that Caucasian silhouette would benefit from surgery (Table 5.7).

Table 5.7: Comparison of participants' rating who thought that a patient would benefit from orthognathic surgery for the Caucasian versus Chinese silhouettes.

Manipulation (mm)	Caucasian Silhouette			Chinese Silhouette		
	Total	**N**	**Percentage (%)**	**Total**	**N**	**Percentage (%)**
0	249	4	1.6	244	4	1.6
Mandible manipulated anteriorly (mm)						
2	246	0	0	242	9	3.7
4	250	10	4	241	51	21.2
6	250	113	45.2	244	153	62.7
8	249	236	94.8	245	213	86.9
10	257	256	99.6	247	239	96.8
Maxilla manipulated posteriorly (mm)						
2	250	4	1.6	243	17	7.0
4	249	16	6.4	241	167	69.3
6	260	234	90.0	242	171	70.7
8	252	248	98.4	243	225	92.6
10	253	252	99.6	247	243	98.4

5.4.5 Mixed logistic regression for benefit from surgery

The univariate and multivariate mixed logistic regressions for the dichotomous outcome 'benefit from surgery' are shown in tables 5.8 and 5.9. All variables with univariate associations at $p<0.25$ were included in multivariate mixed logistic regressions for benefit from surgery. From univariate mixed logistic regression, consultant's years of experience, gender, specialty, the number of orthognathic patients treated per year, and the consideration of the importance of an attractive appearance were not statistically significant factors on the benefit from surgery. Since there was no statistically significant difference between the perception for the benefit from surgery between orthodontists and oral and maxillofacial surgeons (odds ratio=1.11; p=0.176; 95% CI 0.96, 1.28), the results were combined to compare all the clinicians' perception for the benefit from surgery for Caucasian skeletal class III profiles versus Chinese skeletal class III profiles. The silhouette's race was featured as highly statistically significant factor on the benefit from surgery ($p<0.001$).

From multivariate mixed logistic regressions (Table 5.9), the odds of perceived benefit from surgery:

- Decreased by 1% for each year increase in experience of consultant
- Was 32% greater for oral and maxillofacial surgeons than orthodontists
- Was 8% greater for number of orthognathic patients the consultants treat
- Increased 2.87 times for Chinese silhouette than Caucasian silhouette
- Were 2.5 times higher for the silhouette that had 2 mm manipulation of maxilla compared to the silhouette with the same degree of manipulation in the mandible
- Were 9 times higher for the silhouette that had 4 mm manipulation of maxilla compared to the silhouette with the same degree of manipulation in the mandible.
- For the manipulation of 6 mm, 8 mm and 10 mm, there was a general tendency among participants to recommend the surgery more if the manipulated jaw was the maxilla.

Table 5.8: Univariate mixed logistic regression for benefit from surgery

Variable	Odds ratio	95% confidence interval	P-value
Years as a consultant	1.00	0.99, 1.00	0.134
Gender (female vs. male)	1.02	0.91, 1.14	0.738
Specialty (oral and maxillofacial vs. orthodontics)	1.11	0.96, 1.28	0.176
Number of orthognathic patients treated per year*	1.02	0.99, 1.05	0.131
Importance of attractive appearance	0.99	0.92, 1.06	0.772
Race of image (Chinese vs. Caucasian)	1.35	1.22, 1.52	<0.001
Manipulation (vs. none)			
Maxillary 2 mm	2.78	1.21, 6.41	0.016
Maxillary 4 mm	77.67	37.17, 162,33	<0.001
Maxillary 6 mm	540.37	253.63,1151.25	<0.001
Maxillary 8 mm	3464.42	1484.90, 8082.85	<0.001
Maxillary 10 mm	16633.93	5277.99, 52422.96	<0.001
Mandibular 2 mm	1.13	0.43, 2.99	0.799
Mandibular 4 mm	9.58	4.48, 20.48	<0.001
Mandibular 6 mm	114.19	54.57, 238.95	<0.001
Mandibular 8 mm	1477.49	670.59, 3255.17	<0.001
Mandibular 10 mm	9145.34	3408.75, 24536.08	<0.001

* Coefficient refers to increase of 1 category in groupings of 5 patients (0-5, 6-10, etc.)

Table 5.9: Multivariate mixed logistic regressions for benefit from surgery. All variables with univariate associations at p<0.25 included.

Variable	Odds ratio	95% confidence interval	P-value
Years as a consultant	0.99	0.97, 1.01	0.240
Specialty (oral and maxillofacial surgeon vs. orthodontics)	1.32	0.81, 2.16	0.261
Number of orthognathic patients treated per year*	1.08	0.98, 1.19	0.125
Race of image (Chinese vs. Caucasian)	2.87	2.34, 3.52	<0.001
Manipulation (vs. none)			
Maxillary 2 mm	2.84	1.22, 6.58	0.015
Maxillary 4 mm	92.56	43.91, 195.11	<0.001
Maxillary 6 mm	733.82	340.03, 1583.67	<0.001
Maxillary 8 mm	5063.43	2135.16, 12007.66	<0.001
Maxillary 10 mm	24755.43	7745.75, 79118.34	<0.001
Mandibular 2 mm	1.14	0.43, 3.01	0.798
Mandibular 4 mm	10.19	4.73, 21.93	<0.001
Mandibular 6 mm	140.37	66.45, 296.50	<0.001
Mandibular 8 mm	2080.58	930.32, 4652.69	<0.001
Mandibular 10 mm	13591.50	4987.55, 37038.01	<0.001

* Coefficient refers to increase of 1 category in groupings of 5 patients (0-5, 6-10, etc.)

5.5 Perceived attractiveness of silhouettes

5.5.1 Caucasian silhouettes

There was no statistically significant difference between rating the attractiveness of the silhouettes between orthodontists and oral and maxillofacial surgeons (regression coefficient=0.02; p=0.813; 95% CI -0.12, 0.15); therefore, the results were combined to compare all the clinicians' rating the attractiveness of the Caucasian and Chinese silhouettes. The highest rated for the Caucasian silhouettes and thereby most attractive perceived silhouette was silhouette AM, representing the facial profile with very minor mandibular prominence (mandible manipulated 2 mm anteriorly) (Figure 5.9). This was followed by AS (maxilla manipulated 2 mm posteriorly) and then the third highly ranked as most attractive silhouette was FS which represents the ideal facial profile. The lowest rated silhouettes (NS and SM) demonstrate the most severe degrees of maxillary retrusion and mandibular protrusion (Table, 5.10).

Figure 5.9 Participants rated AM as the most attractive, SM and NS as the lease attractive Caucasian silhouettes

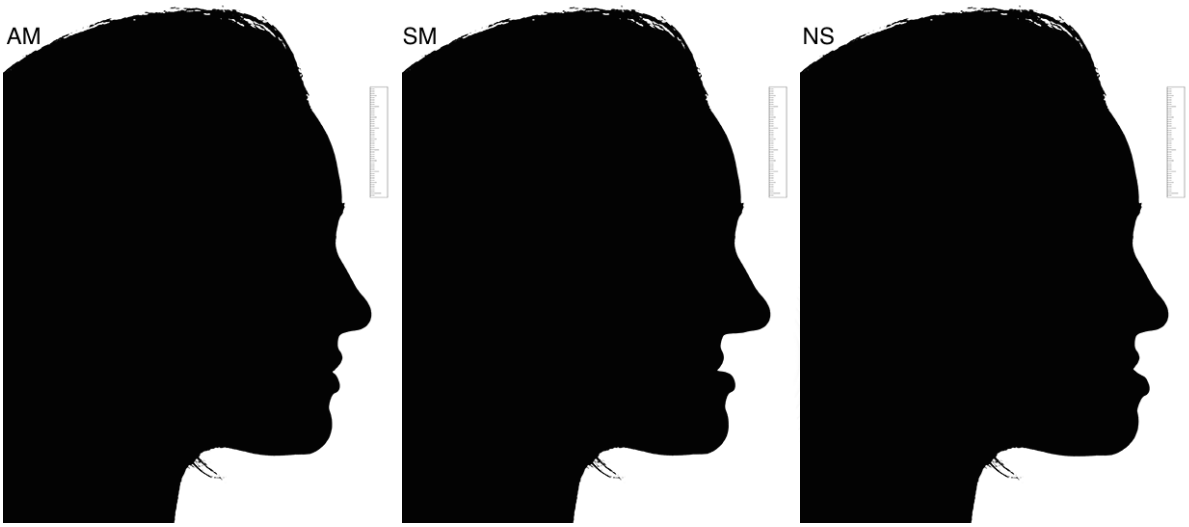


Table 5.10: Participants' rating for the Caucasian silhouettes, when asked how they would rate the attractiveness on 7-point Likert scale.

Silhouette code	Manipulation (mm)	Total	Likert scale			
			Minimum Score	**Maximum Score**	**Mean (95% CI)**	**Standard Deviation**
FS	0	249	3	7	5.39 (5.29, 5.49)	0.80
	Mandible manipulated anteriorly (mm)					
AM	2	246	3	7	5.52 (5.42, 5.62)	0.78
EW	4	250	3	7	4.92 (4.82, 5.03)	0.83
RS	6	250	2	6	3.76 (3.65, 3.86)	0.83
MA	8	248	1	5	2.58 (2.49, 2.67)	0.72
NS	10	257	1	5	2.10 (2.01, 2.19)	0.77
	Maxilla manipulated posteriorly (mm)					
AS	2	250	2	7	5.47 (5.36, 5.57)	0.84
MF	4	249	2	7	4.72 (4.61, 4.83)	0.86
LR	6	261	1	7	3.07 (2.97, 3.16)	0.78
MH	8	257	1	5	2.65 (2.56, 2.75)	0.76
SM	10	253	1	5	1.99 (1.09, 2.08)	0.72

5.5.2 Chinese silhouettes

The highest rated for the Chinese silhouettes and thereby most attractive perceived silhouette was FM, representing ideal facial profile (Figure 5.10). Other highly rated images exhibited minor degrees of mandibular protrusion (DC) or maxillary retrusion (SR). The lowest rated silhouettes (ZA and SC) demonstrate the most severe degrees of maxillary retrusion and mandibular protrusion respectively (Table 5.11).

Figure 5.10 Participants rated FM as the most attractive, ZA and SC as the lease attractive Chinese silhouettes

Table 5.11: Participants' rating for the Chinese silhouettes, when asked how they would rate the attractiveness on 7-point Likert scale.

Silhouette code	Manipulation (mm)	Total	Likert scale			
			Minimum Score	**Maximum Score**	**Mean (95% CI)**	**Standard Deviation**
FM	0	244	3	6	4.79 (4.69, 4.90)	0.80
	Mandible manipulated anteriorly (mm)					
DC	2	242	3	6	4.63 (4.53, 4.73)	0.77
DG	4	241	2	6	3.88 (3.77, 3.99)	0.85
CD	6	244	1	5	3.08 (2.98, 3.17)	0.76
MS	8	245	1	4	2.49 (2.39, 2.59)	0.77
ZA	10	247	1	4	1.85 (1.79, 1.93)	0.71
	Maxilla manipulated posteriorly (mm)					
SR	2	243	2	6	4.26 (4.16, 4.36)	0.79
GR	4	247	1	4	2.42 (2.32, 2.52)	0.80
MT	6	242	1	5	2.98 (2.90, 3.06)	0.65
SH	8	243	1	4	2.38 (2.29, 2.46)	0.67
SC	10	247	1	4	1.85 (1.75, 1.95)	0.77

5.5.3 Caucasian versus Chinese silhouettes

To summarise the previous two sections, table 5.12 demonstrates a comparison of participants' ratings for the Caucasian and Chinese silhouettes. This shows that Caucasian silhouettes are rated higher in term of level of attractiveness than Chinese silhouettes with the same degree of manipulation. For the maxillary manipulation of 2 mm compared with 4 mm, the participants' rating for attractiveness changed from 5.47 to 4.72 for Caucasian silhouettes and 4.26 to 2.42 for the Chinese silhouettes.

Table 5.12: Comparison of participants' rating for attractiveness for Caucasian versus Chinese silhouettes

Manipulation (mm)	Caucasian Silhouettes		Chinese Silhouettes	
	Mean (95% CI)	**Standard Deviation**	**Mean (95% CI)**	**Standard Deviation**
0	5.39 (5.29, 5.49)	0.80	4.79 (4.69, 4.90)	0.80
Mandible manipulated anteriorly (mm)				
2	5.52 (5.42, 5.62)	0.78	4.63 (4.53, 4.73)	0.77
4	4.92 (4.82, 5.03)	0.83	3.88 (3.77, 3.99)	0.85
6	3.76 (3.65, 3.86)	0.83	3.08 (2.98, 3.17)	0.76
8	2.58 (2.49, 2.67)	0.72	2.49 (2.39, 2.59)	0.77
10	2.10 (2.01, 2.19)	0.77	1.85 (1.79, 1.93)	0.71
Maxilla manipulated posteriorly (mm)				
2	5.47 (5.36, 5.57)	0.84	4.26 (4.16, 4.36)	0.79
4	4.72 (4.61, 4.83)	0.86	2.42 (2.32, 2.52)	0.80
6	3.07 (2.97, 3.16)	0.78	2.98 (2.90, 3.06)	0.65
8	2.65 (2.56, 2.75)	0.76	2.38 (2.29, 2.46)	0.67
10	1.99 (1.09, 2.08)	0.72	1.85 (1.75, 1.95)	0.77

5.5.4 Mixed linear regression for attractiveness rating

The univariate and multivariate mixed linear regressions for attractiveness rating are shown in tables 5.13 and 5.14. Since there was no statistically significant difference between rating the attractiveness of the silhouettes between orthodontists and oral and maxillofacial surgeons (regression coefficient=0.02; p=0.813; 95% CI -0.12, 0.15), the results were combined to compare all the clinicians' rating the attractiveness of the Caucasian and Chinese silhouettes. All variables with univariate associations at p<0.25 were included in multivariate mixed linear regressions for participants' rating for attractiveness. From univariate mixed linear regression, consultant's years of experience, gender, specialty, the number of orthognathic patients treated per year, and the consideration of the importance of an attractive appearance were not statistically significant factors on rating the attractiveness of the silhouettes. However, the silhouette's race was highly statistically significant factor on rating the attractiveness (p<0.001). The ratings of Chinese silhouettes are 0.68 of a level of Likert scale less than the ratings of the Caucasian silhouettes. For the type of manipulation, all maxillary manipulated silhouettes were considered less attractive than mandibular manipulated silhouette with the same degree of manipulation. From multivariate mixed linear regressions (Table 5.14), the rating of silhouette attractiveness:

- Decreased by 0.02 of a level of Likert scale for each year increase in experience of consultant
- Decreased by 0.02 of a level of Likert scale the more number of orthognathic patients the consultants treat
- Decreased by 0.68 of a level of Likert scale for Chinese silhouette compared to Caucasian silhouette
- All maxillary manipulated silhouettes were considered less attractive than mandibular manipulated silhouette with the same degree of manipulation

Table 5.13: Univariate mixed linear regression for attractiveness rating.

Variable	Regression coefficient (gradient)	95% confidence interval	P-value
Years as a consultant	0.0007	(-0.006, 0.007)	0.838
Gender (female vs. male)	0.02	(-0.09, 0.12)	0.731
Specialty (oral and maxillofacial vs. orthodontics)	0.02	(-0.12, 0.15)	0.813
Number of orthognathic patients treated per year*	-0.02	(-0.05, 0.003)	0.086
Importance of attractive appearance	0.06	(-0.01, 0.13)	0.080
Race of image (Chinese vs. Caucasian)	-0.68	(0.61, 0.75)	<0.001
Manipulation (vs. none)			
Maxillary 2 mm	-0.23	(-0.33, -0.12)	<0.001
Maxillary 4 mm	-1.52	(-1.63, -1.42)	<0.001
Maxillary 6 mm	-2.08	(-2.18, -1.98)	<0.001
Maxillary 8 mm	-2.58	(-2.69, -2.48)	<0.001
Maxillary 10 mm	-3.18	(-3.28, -3.08)	<0.001
Mandibular 2 mm	-0.02	(-0.12, 0.09)	0.752
Mandibular 4 mm	-0.68	(-0.79, -0.58)	<0.001
Mandibular 6 mm	-1.68	(-1.78, -1.58)	<0.001
Mandibular 8 mm	-2.56	(-2.66, -2.46)	<0.001
Mandibular 10 mm	-3.13	(-3.23, -3.03)	<0.001

* Coefficient refers to increase of 1 category in groupings of 5 patients (0-5, 6-10, etc.)

Table 5.14: Multivariate mixed linear regressions for attractiveness rating. All variables with univariate associations at p<0.25 were included.

Variable	Regression coefficient (gradient)	95% confidence interval	*P*-value
Number of orthognathic patients treated per year*	-0.02	(-0.05, 0.01)	0.127
Importance of attractive appearance	0.05	(-0.01, 0.12)	0.119
Race of image (Chinese vs. Caucasian)	-0.68	(0.64, 0.72)	<0.001
Manipulation (vs. none)			
Maxillary 2 mm	-0.23	(-0.32, -0.14)	<0.001
Maxillary 4 mm	-1.52	(-1.61, -1.43)	<0.001
Maxillary 6 mm	-2.09	(-2.18, -1.99)	<0.001
Maxillary 8 mm	-2.59	(-2.68, -2.49)	<0.001
Maxillary 10 mm	-3.18	(-3.27, -3.09)	<0.001
Mandibular 2 mm	-0.02	(-0.11, 0.08)	0.722
Mandibular 4 mm	-0.69	(-0.78, -0.59)	<0.001
Mandibular 6 mm	-1.68	(-1.77, -1.58)	<0.001
Mandibular 8 mm	-2.56	(-2.65, -2.47)	<0.001
Mandibular 10 mm	-3.13	(-3.22, -3.04)	<0.001

* Coefficient refers to increase of 1 category in groupings of 5 patients (0-5, 6-10, etc.)

5.5.5 Most attractive and least attractive silhouettes

The overall data collected showed that the most attractive profile was AM, Caucasian silhouette with mandible manipulated 2 mm anteriorly. The first four attractive silhouettes were Caucasian silhouettes. The least attractive silhouette was SC, which is Chinese silhouette with 10 mm mandible manipulation. The data is shown in table 5.15.

Table 5.15: Consultants ratings for profile attractiveness in descending order from most to least attractive silhouette

Silhouette code	Race	Manipulation (mm)	Jaw	Mean	95% Confidence Intervals
AM	Caucasian	2	Mandible	5.52	(5.42, 5.62)
AS	Caucasian	2	Maxilla	5.47	(5.36, 5.57)
FS	Caucasian	0	-	5.39	(5.29, 5.49)
EW	Caucasian	4	Mandible	4.92	(4.82, 5.03)
FM	Chinese	0	-	4.79	(4.69, 4.90)
MF	Caucasian	4	Maxilla	4.72	(4.61, 4.83)
DC	Chinese	2	Mandible	4.63	(4.53, 4.73)
SR	Chinese	2	Maxilla	4.26	(4.16, 4.36)
DG	Chinese	4	Mandible	3.88	(3.77, 3.99)
RS	Caucasian	6	Mandible	3.76	(3.65, 3.86)
CD	Chinese	6	Mandible	3.08	(2.98, 3.17)
LR	Caucasian	6	Maxilla	3.07	(2.97, 3.16)
MT	Chinese	6	Maxilla	2.98	(2.90, 3.06)
MH	Caucasian	8	Maxilla	2.65	(2.56, 2.75)
MA	Caucasian	8	Mandible	2.58	(2.49, 2.67)
MS	Chinese	8	Mandible	2.49	(2.39, 2.59)
GR	Chinese	4	Maxilla	2.42	(2.32, 2.52)
SH	Chinese	8	Maxilla	2.38	(2.29, 2.46)
NS	Caucasian	10	Mandible	2.10	(2.01, 2.19)
SM	Caucasian	10	Maxilla	1.99	(1.09, 2.08)
ZA	Chinese	10	Maxilla	1.85	(1.79, 1.93)
SC	Chinese	10	Mandible	1.85	(1.75, 1.95)

6 Discussion

6.1 Introduction

This study was a cross-sectional survey conducted from April 2015 to July 2015. The questionnaire was distributed to all consultant orthodontists and consultant oral and maxillofacial surgeons in United Kingdom using the mailing lists of the British Orthodontic Society (BOS) and British Association of Oral and Maxillofacial Surgeons (BAOMS), respectively. This study aimed to investigate the impact of patients' race on influencing whether clinicians perceive a facial benefit from orthognathic surgery in patients with class III skeletal bases.

In comparison to Caucasians, Chinese people have a less convex profile, the upper lip is more protrusive, the nasiolabial angle is less obtuse and the maxillary position is retruded[(69)]. These are the features of class III skeletal profile for a Caucasian patient. Therefore, it was interesting to explore whether the clinicians appreciate this racial anatomical variations or if they recommend the surgery based on Caucasian norms. This study was therefore focused on exploring whether patients' racial differences influence clinicians when recommending surgery to their patients.

6.2 Summary of findings

This section will summarise the most important findings of this study.

- The overall response rate for this study was 273 (66.1%).
- Consultant orthodontists' group response rate was 221 (70.1%) and oral and maxillofacial surgeon group response rate was 52 (53%).
- The majority of participants (82%) were White British and White Irish consultant orthodontists and consultant oral and maxillofacial surgeons.
- From univariate mixed logistic regression, there was no statistically significant difference between the perception of the benefit from orthognathic surgery between consultant orthodontists and consultant oral and maxillofacial surgeons (odds ratio=1.11; p=0.176; 95% CI 0.96, 1.28).
- The silhouette's race was found to be a highly statistically significant factor related to the perceived benefit from surgery (p<0.001). The odds of clinicians perceiving a benefit from surgery and therefore recommending an

orthognathic surgery increased 2.87 times for a Chinese silhouette than a Caucasian silhouette with class III skeletal bases.

- Consultant's years of experience, gender, specialty, the number of orthognathic patients treated per year, and the consideration of the importance of an attractive appearance were not statistically significant factors on their decision to perceive a benefit from orthognathic surgery.
- From the multivariate mixed logistic regressions analysis for the odds of perceived benefit from surgery, there was a general tendency among participants to recommend the surgery more if the manipulated jaw was the maxilla. All maxillary manipulated silhouettes were considered less attractive than mandibular manipulated silhouette with the same degree of manipulation.
- For maxillary manipulated silhouettes, more than two-thirds of participants thought that Chinese silhouette would benefit from surgery compared to only 6.4% of the participants thought that Caucasian silhouette would benefit from surgery.
- There was no statistically significant difference between rating the attractiveness of the silhouettes between orthodontists and oral and maxillofacial surgeons (regression coefficient=0.02; p=0.813; 95% CI -0.12, 0.15), the results were combined to compare all the clinicians' rating the attractiveness of the Caucasian and Chinese silhouettes.
- Consultant's years of experience, gender, specialty, the number of orthognathic patients treated per year, and the consideration of the importance of an attractive appearance were not statistically significant factors on rating the attractiveness of the silhouettes.
- The silhouette's race was highly statistically significant factor on rating the attractiveness ($p<0.001$). The ratings of Chinese silhouettes are 0.68 of a level of Likert scale less than the ratings of the Caucasian silhouettes.
- The participants of this study considered the Caucasian profile more attractive than the Chinese profile.

These findings suggest that clinicians, who majority of them were White, prefer the Caucasian profile and rated a perceived benefit from orthognathic surgery for

Chinese profiles based on the Caucasian norms. Therefore, these clinicians might tend to offer surgery for Chinese patient more often than Caucasian patients.

6.3 Comparisons with other studies

6.3.1 Benefit from surgery

In this study, there was no statistically significant difference between the perception for the facial benefit from orthognathic surgery between consultant orthodontists' and consultant oral and maxillofacial surgeons (odds ratio=1.11; p=0.176; 95% CI 0.96, 1.28). These findings are similar to other studies[81,82,98] reported in the literature that showed a general agreement between orthodontists and oral and maxillofacial surgeons regarding the patients' benefit from orthognathic surgery. This contradict findings the by Arpino *et al*[99] that orthodontists are more tolerant to facial changes than oral and maxillofacial surgeons. However, the Arpino's study involved a very small sample size (only three orthodontists and three oral surgeons). Almeida *et al*[84] reported that oral and maxillofacial surgeons were more likely to indicate ahead for orthognathic surgery than laypersons and orthodontists. However, the question in that study was slightly different to our study which was would you seek facial surgery if profiles were your own? This would affect the participants' judgement when answering the questions.

The silhouette's race was a highly statistically significant factor on the benefit from surgery ($p<0.001$). The odds of clinicians perceiving a benefit from surgery and therefore recommending an orthognathic surgery increased 2.87 times for a Chinese silhouette than a Caucasian silhouette with class III skeletal bases. With regards to degree of manipulation and silhouettes' race, more than two-thirds of clinicians thought that Chinese silhouette would benefit from surgery compared to only 6.4% of the clinicians thought that Caucasian silhouette would benefit from surgery for the maxillary manipulation of 4 mm. There has been no previous study to compare these finding to it. One study[84] however has previously compared Whites to Black patients and found no significant difference among clinicians in terms of the perception for benefit from orthognathic surgery.

Consultant's years of experience, gender, specialty, the number of orthognathic patients treated per year, and the consideration of the importance of an attractive appearance were not statistically significant factors on their perception of benefit from orthognathic surgery. These findings agree with those of a similar study conducted in United Kingdom by Hodge *et al*[100], which showed that neither the consultant's sex nor the year of qualification seemed to affect this decision. However, they found that the more orthognathic patients a consultant orthodontist treats per year, the more likely he or she is to recommend surgery. On the other hand, Naini *et al*[82] found that observer age, gender, featured as statistically significant factors on the desire for surgery.

This study explored the extent to which maxillary retrusion or mandibular prognathism influences whether clinicians recommend surgery to patients. From the multivariate mixed logistic regressions analysis for the odds of benefit from surgery, there was a general tendency among participants to recommend the surgery more if the manipulated jaw was the maxilla. There was no previous study that have compared the maxillary to mandibular manipulation and their effect on participants' clinical judgment. Communication with those working in this area to establish any future silhouette studies that include maxillary manipulation confirmed that this study as far as they were aware would be original[101].

6.3.2 Perception of attractiveness

Facial attractiveness is a multifactorial concept. It would be interesting to explore the clinicians' factor that might affect their perception of attractiveness. In this study, consultant's years of experience, gender, specialty, the number of orthognathic patients treated per year, and the consideration of the importance of an attractive appearance were not statistically significant factors on rating the attractiveness of the silhouettes. Moreover, there was no statistically significant difference between the consultant orthodontists and oral and maxillofacial surgeons. An unpublished thesis[102] carried out at University of Alabama at Birmingham found that the rater category (layperson, orthodontists and oral surgeons) had no effect on the facial attractiveness rating. This contradicts the finding by Naini *et al*[82] that observer age, gender, consideration of the importance of an attractive appearance, and the

consideration of the importance of an attractive were statistically significant factors on the rating the attractiveness. However, Naini *et al*[82] study had a smaller sample size of only 35 clinicians involved, which makes the study conclusions weaker.

The silhouette's race was a highly statistically significant factor on rating the attractiveness ($p<0.001$). The clinicians considered the Caucasian profile more attractive than the Chinese profile. Berstein *et al*[103] looked at the cross versus within racial judgment of attractiveness and found that Black and White aesthetic criteria were more like one another than were Chinese and White criteria.

An interesting finding was that the most attractive profile perceived by participants was AM (mandible manipulated 2 mm anteriorly). This contradicts the findings by Naini *et al*[81] and Johnston *et al*[104] studies that found that participants preferred the ideal profile. However, there was a very small difference between AM and the ideal profile. Therefore, this finding should be interpreted with caution.

A study[105] that involved rating of facial attractiveness of end-of-treatment facial photographs of 43 White patients and 48 Chinese patients by pairs of White and Chinese orthodontists. They found that the pair of Chinese orthodontists agreed with each other slightly better on average when ranking Chinese patients. Also, the pair of White orthodontists agreed with each other slightly better on average when ranking white American patients, but the overall differences were small. This highlights the effect of clinician's ethnic background on their perception of attractiveness; however, the sample size of the clinicians of that study was small (2 White and 2 Chinese orthodontists) to be able to draw definitive conclusions. Unfortunately, majority of participants in our study was were White Caucasians with small numbers of other ethnic groups. Therefore, the effect of clinician's ethnic background could not be explored.

6.4 Limitations of study

6.4.1 Response rate

The average response rate reported in the dental literature was 64 per cent[106]. In the current study, the response rate of the consultant orthodontists group was 70.1%, which is higher than the average response rate. This can be explained by several reasons. First of all the use of adjunct postal questionnaire, and the questionnaires were signed by a consultant orthodontist (N.F). In addition, the follow up of non responders, the use of colours in the booklet and the fact that the questionnaire came from a university might contributed this increased response rate[92].

For the oral and maxillofacial surgeon group, the response rate was 53%, which was slightly lower than the average response rate of dental questionnaires[106]. The fact that we could not follow up of non responders and limited number of reminders sent by the BAOMS might explain this low response rate. We would anticipate if the questionnaires had been sent out by post for the oral and maxillofacial surgeons as well as web-based , the response rate might be higher.

The BAOMS regulations were to send web-based questionnaires only; therefore, we were not able to use the sequential mixed mode for the oral and maxillofacial surgeons group. The only way to overcome this was by getting a full list of oral and maxillofacial surgeons with their contact details. However, this would have been very difficult to obtain a complete list of oral and maxillofacial surgeons who are interested in orthognathic surgery other than through the BAOMS, which is bound by data protection law in the use of its membership details and mailing lists.

6.4.2 Validity of measures

The sole use of silhouettes to decide the benefit from orthognathic surgery did not mimic a real-life situation. The clinical judgment for the benefit from surgery would be based on the patient's chief complaint. In an ideal case scenario, the clinician would have all the patient records in order to evaluate the benefit for surgery, especially for borderline cases. However, it was not possible to mimic every clinical scenario and

the current study was particularly interested on the effect of the patient's race to recommend surgery for the patients.

The use of a 7 point Likert scale was found to have equivalent construct validity to Visual Analogue Scale in sports medicine[107] and it is widely used in psychology literature[74]. It offers a reasonable comparison between the web-based and paper questionnaire. This is due to the fact that web-based questionnaires could be completed on a computer desktop or laptop, a tablet or a smart phone. This might potentially affects the results of the study if we used a Visual Analogue Scale.

6.4.3 Reliability of measures

There was a significant difference in the clinicians' ratings for the borderline silhouette (GR) and its duplicate (Table 5.2). In the questionnaire, silhouette GR was after a 10 mm manipulated mandible silhouette and the duplicate was after a 2 mm manipulated maxilla silhouette. This was rated lower for the benefit from surgery when it followed a large manipulated silhouette and higher when it followed a slightly manipulated silhouette.

The implications of this finding are that if a new patient clinic were to be full of severe cases, this might affect the clinician's judgment for borderline cases. The clinician would be more inclined not to offer an orthognathic surgery for borderline cases. Conversely, if a new patient clinic were full of mild cases, a clinician might tend to offer the orthognathic surgery for borderline case. This might be explained by the occurrence of priming which is the implicit memory effect in which the exposure to one stimulus would affect the response to other stimulus. There are different types of priming but the simplest example to this concept may be a word fragment completion task. The participants of this test would easily identify the word "nurse" if it was followed by the word "doctor" than when it was followed by the word "butter"[108].

6.5 Discussion of the methods

6.5.1 Target Groups

The decision for orthognathic surgery is usually made through joint orthodontic-surgical clinics that involve collaborative work between consultant orthodontists and maxillofacial surgeons. Therefore, this questionnaire involved both consultant orthodontists and consultant maxillofacial surgeons. To make the results of this study generalisable, the questionnaire was sent to all consultant orthodontists and maxillofacial surgeons in the United Kingdom. It would be interesting to expand the study into other countries to give an idea as to whether the ethnic background of the clinicians influenced their responses. In my study the sample was too homogenous with mainly White British participants.

6.5.2 Sequential mixed mode

The sequential mixed-mode design has been reported to be successful in increasing overall response rate when used in distributing the questionnaire to medical nurses[109]. It has been found that response rate can be improved even further by offering an alternative response format for participants especially if participants have a mode preference[110]. Therefore, the decision was made to use a mixed mode approach. The sequential mixed mode found to be very effective in terms of achieving a very good response rate.

In this study, the response rate was 70.1% when the sequential mixed mode approach was used for the consultant orthodontic group compared to the response rate was 53% when web-based mode was used for the consultant oral and maxillofacial surgeons group. We might expect that response rate could be improved still further by offering an alternative response format for oral and maxillofacial group, although the relatively high response orthodontist may be due to other factors for example the letter was signed by an orthodontist and not by an oral and maxillofacial surgeon. Fewer reminders being sent compared to orthodontists group might explain the lower response rate among oral maxillofacial surgeons. This could not be helped because we did not have any control on the number of reminders sent by the secretaries of BOS or BAOMS.

6.5.3 Design of the questionnaire

Various measures were taken to increase the response rate. There are many strategies learned from previous research that could increase the response rate. These can be related to the questionnaire design with regard to its content, length, type of questions and format of questions[111]. The length of the questionnaire affects the response rate; for instance, a comparison of questionnaires of varying length found a threshold of 1,000 words, above which response rates start to drop off[112]. Previous literature[113-116] concurs with this finding that the shorter the questionnaire, the higher the response rate. The word count for our questionnaire was 1,557 words however the questions were repeated for every silhouette so the participants scan through the silhouettes smoothly. In addition, evidence indicates that the use of closed-ended questions, rather than open-ended questions, increases the response rate by 22 per cent[117]. The current study used questions in a closed-ended format and as few as possible silhouettes. We piloted it in a group of University of Liverpool Dental hospital consultants and registrars to make sure it was reasonable.

The design of the web-based questionnaire followed design standards suggested by Crawford *et al.*[91] to increase the response rate. These strategies were previously discussed in section 2.5. The content of the wed-based and paper questionnaires was the same; however, the format for the paper version was developed using Microsoft Word and following strategies suggested by Edward *et al.*[92] to improve the postal questionnaire response rate. For this study, the paper copy of the questionnaire was printed in coloured ink and first class, stamped return envelopes were used to increase the response rate[92]. In addition, Liverpool University, BOS and BAOMS logos were used at the cover page of the invitation letter and the questionnaire because questionnaires originating from universities were more likely to be returned than those from other sources such as commercial organisations[92]. The participants were contacted via invitation letter before sending the questionnaire because it was found that a higher response rate would be obtained when the participant contacted earlier [92].

One of the most important factors, which has been identified as being associated with higher response rates, is that the topic of the study should be relevant to the

participants' profession[92]. A recent literature review of conducting questionnaires among physicians by Flanigan *et al*.[118] reported that a higher response rate was obtained for questionnaires concerning physicians' attitudes about issues relevant to their practice of medicine[116]. The current study could be seen as being related to clinicians' everyday practice thus a high response rate may be expected.

With regards to completion rate of the questionnaires, the web-based mode had 94% completed questionnaires compared to paper mode which had 72% completed questionnaires. This concurs with previous studies which have found that questionnaires sent by e-mail have fewer incomplete answers compared to the same questionnaires sent by postal mail or fax[88].

6.6 Future area of research

It would be interesting to repeat this study for Chinese orthodontists and oral and maxillofacial surgeons to compare their responses with our findings. Currently I am supervising an undergraduate student for her elective study project. The project will involve repeating this study in Hong Kong to explore the Chinese clinicians' responses in comparison to the UK clinicians. This study can be repeated to different racial groups. Also, the effect of priming can be explored by ordering the silhouettes intentionally rather than simple random order.

In addition, the use of frontal as well as profile patients' photographs instead of silhouettes and different patients rather than computer-manipulated images. However, confounding factors should be considered. These confounding factors can be the facial height, the chin prominence, the chin to throat length, the nasiolabial angle, and all other facial angle that might affect clinician judgment.

There has been advances in the three dimensional (3D) imaging techniques for example 3D laser scanning and stereophotogrammetry. They can be used in orthodontics for treatment planning and review development of dentition and skeletal pattern[119]. They also can be used in orthodontic research because they would have more reflection of the real life situation. However, these 3D imaging techniques require expensive software, staff training and can be time consuming.

This study involved the use of female silhouettes so it would be interesting if we could repeat it for Caucasian and Chinese males and compare the findings. Laypersons and orthognathic patients should be involved in a study of this type because orthognathic surgery is an elective procedure. Therefore, clinicians should be driven by patients' aesthetic view as well as their clinical judgment. Previous studies[8] showed that orthognathic patients have different perception with regards to aesthetic views than clinician. Therefore, future studies should consider also this difference and involve orthognathic patients as a participant group.

7 Conclusions

The results of this investigation indicate there is no statistically significant difference between the perception for the benefit from orthognathic surgery between consultant orthodontists' and consultant oral and maxillofacial surgeons (p=0.176). The answer to our research question, which was: "Does the racial background of the patient influence clinicians' perception of the benefit from orthognathic surgery in patients presenting with class III skeletal discrepancies?", is therefore "Yes". The odds of clinicians perceiving a benefit from surgery and therefore recommending an orthognathic surgery increased 2.87 times for a Chinese silhouette than a Caucasian silhouette with class III skeletal bases ($p<0.001$).

Consultant's years of experience, gender, specialty, the number of orthognathic patients treated per year, and the consideration of the importance of an attractive appearance were not statistically significant factors on their decision to perceive a benefit from orthognathic surgery nor rating the attractiveness of the silhouettes.

From the multivariate mixed logistic regressions analysis for the odds of benefit from surgery, there was a general tendency among participants to recommend the surgery more if the manipulated jaw was the maxilla. For the maxillary manipulation of 4 mm, more than two-thirds of clinicians thought that Chinese silhouette would benefit from surgery compared to only 6.4% of the clinicians thought that Caucasian silhouette would benefit from surgery.

The clinicians considered the Caucasian profile more attractive than the Chinese one (regression coefficient -0.68; CI 0.61, 0.75; $p<0.001$). From the multivariate mixed linear regressions analysis for attractiveness rating, the ratings of Chinese silhouettes were 0.68 of a level of Likert scale less than the ratings of the Caucasian silhouettes. All maxillary manipulated silhouettes were considered less attractive than mandibular manipulated silhouette with the same degree of manipulation.

8 References

1. Shaw W, Rees G, Dawe M, Charles C. The influence of dentofacial appearance on the social attractiveness of young adults. American Journal of Orthodontics. 1985; 87: 21–26.
2. Kerosuo H, Hausen H, Laine T, Shaw W. The influence of incisal malocclusion on the social attractiveness of young adults in Finland. European Journal of Orthodontics. 1995; 17: 505–512.
3. Birkeland K, Boe O, Wisth P. Relationship between occlusion and satisfaction with dental appearance in orthodontically treated and untreated groups. A longitudinal study. European Journal of Orthodontics. 2000; 22: p. 509–518.
4. Kiekens R, Maltha J, van't Hof M, Kuijpers-Jegtman A. Objective measures as indicators for facial esthetics in white adolescents. Angle Orthodontist. 2006; 76: 551–556.
5. Ackerman JL,Proffit WR. Soft tissue limitations in orthodontics: treatment planning guidelines. Angle orthodontist. 1991; 67(5):327-336.
6. Mills J. A clinician look at facial growth. British Journal of Orthodontics. 1983; 10: 58-72.
7. Proffit WR, White RP, Sarver DM. Contemporary treatment of dentofacial deformity. St. Louis: Mosby; 2013.
8. Juggins K, Nixon F, Cunningham S. Patient- and clinician-perceived need for orthognathic surgery. American Journal Orthodontic Dentofacial Orthop edic. 2005; 128: 697-702.
9. Baccetti T, Franchi L, McNamara J. Growth in the Untreated Class III Subject. Seminars in Orthodontics. 2007; 13: 130-142.
10. Mucedero M, Coviello A, Baccetti T, Franchi L, Cozza P. Stability Factors After Double-Jaw Surgery in Class III Malocclusion: A Systematic Review. Angle Orthodontist. 2008; 78(6): 1141-52
11. Foster EJ. Profile preferences among diversified groups. Angle Orthodontist. 1973; 43: 34-40.
12. Chong HT, Thea KM, Descallar J, Chen Y, Dalci OW, Wong R. Comparison of White and Chinese perception of esthetic Chinese lip position. Angle Orthodontist. 2014; 84: 246–253.
13. Houston W, Stephens C, Tulley W. A text book of orthodontics. 2nd ed.: Wright Publication; 1992.
14. Angle E. Classification of malocclusion. 1898; 41: 248-264. Cited from Almeida MR, Pereira ALP, Almeida RR, Almeida-Pedrin RR, Silva FOG. Prevalence of malocclusion in children aged 7 to 12 years. Dental Press Journal of Orthodontics. 2011;16(4):123-131.
15. Andrews LF. The six keys to normal occlusion. American Journal of Orthodontics. 1972; 62: 296-309.
16. British Standards Institute. Glossary of dental terms. 1983.
17. Todd J, Lader D. Adult dental health. 1988.
18. Cobourne M, Dibiase A. Handbook of orthodontics. 2nd ed. London: Elsevier; 2016.
19. Williams P, Roberts-Harry D, Sandy J.Orthodontics. Part 7: Fact and fantasy in orthodontics. British Dental Journal. 2004; 196(3): 143-148.
20. Maia S, Raveli DB, Santos-Pinto A, Raveli TB, Gomez SP.Computed Tomographic evaluation of a young adult treated with the Herbst appliance. Dental Press Journal of Orthodontics. 2010; 15(5): 130-136.
21. Petrovic A. Is it possible to modulate the growth of the human mandible with a functional appliance?. International Journal of Orthodontics. 1991; 29(1-2): 3-8.
22. Hagg U. Long-term follow-up of early treatment with reverse headgear. European Journal of Orthodontics. 2003; 25(1): 95-102.
23. Mills JR. The effect of functional appliances on the skeletal pattern. British Journal of Orthodontics. 1991; 18(4): 267-275.

24. Weaver N, Glover K, Major P, Varnhagen C, Grace M. Age limitation on provision of orthopaedic therapy and orthognathic surgery. American Journal of Orthodontics and Dentofacial Orthopedics. 1998; 113(2): 156-64.
25. Proffit WR, Phillips C, Tulloch JF, Medland PH. Surgical versus orthodontic correction of skeletal Class II malocclusion in adolescents: effects and indications. International Journal of Adult Orthodontics and Orthognathic Surgery. 1992; 7: 209-20.
26. Proffit W. Equillibrium theory revisited. Angle orthodontic. 1978; 48: 175-186.
27. Proffit WR, White RP. Surgical-orthodontic treatment. United States of America: Mosby; 1991.
28. Flanary C, Barnwell G, Alexander J. Patient perceptions of orthognathic surgery. American Journal of Orthodontic and Dentofacial Orthopedic. 1985; 88: 137-145.
29. Laufer D, Glick D, Gutman D, Sharon A. Patient motivation and response to surgical correction of prognathism. Oral Surgery, Oral Medicine and Oral Pathology. 1976; 41: 309-313.
30. Athanasiou A, Melson B, Eriksen J. Concerns, motivation and experience of orthognathic surgery patients: retrospective study of 152 patients. International Journal of Adult Orthodontics and Orthognathic Surgery. 1989; 4: 47-55.
31. Naini F, Moss J, Gill D. The enigma of facial beauty: esthetics, proportions, deformity and contraversy. American Journal of Orthodontics and Dentofacial Orthopedics. 2006; 130: 277-282.
32. McGregor F. Social and psychological implications of dentofacial disfigurement. Angle Orthodontics. 1970; 40: 231-233.
33. Angle E. Double resection of the lower maxilla. Dental Cosmos. 1898; 40: 635. Cited from Hoffman GR, Moloney FB. The stability of facial osteotomies. 1. The evolution of maxillary, mandibular and chin osteotomies. Australian Dental Journal. 1995;40: 185-3.
34. Babcock W. Surgical treatment of certain deformities of jaw associated with malocclusion of teeth. The Journal of American Medical Association. 1909; 53: p. 833. Cited from Hoffman GR, Moloney FB. The stability of facial osteotomies. 1. The evolution of maxillary, mandibular and chin osteotomies. Australian Dental Journal. 1995;40: 185-3.
35. Steinhäuser E. Historical development of orthognathic surgery. Journal of Craniomaxillofacial Surgery. 1996; 24(4): 195-204.
36. Ayoub AF, Moos KF, Wood GA. Complications following orthognathic surgery that required early surgical intervention: Fifteen years' experience. International Journal of Adult Orthodontic and Orthognathic Surgery. 2001;16: 138–144
37. Patel PK, Morris DE, Gassman A. Complications of orthognathic surgery. Journal of Craniofacial Surgery. 2007 ; 18: 975-85.
38. Esteves L S, Ávila C, Medeiros P J. Changes in occlusal plane through orthognathic surgery. Dental Press Journal of Orthodontics. 2012; 17(4): 160-173.
39. Morris D. Improving standards in orthognathic care: the bigger picture (a national and international perspective). Journal of Orthodontics. 2006 ; 33(3): 149-151.
40. Posnick J. Principles and Practice of Orthognathic Surgery. 1st ed. Missouri: Elsevier Health Sciences; 2013.
41. Robinson RC, Holm RL. Orthognathic surgery for patients with maxillofacial deformities. AORN J. 2010; 92: 28–52.
42. Wenrich MD, Curtis JR, Shannon SE, Carline JD, Ambrozy DM, Ramsey PG. Communicating with dying patients within the spectrum of medical care from terminal diagnosis to death. Archives of Internal Medicine. 2001; 161(6): 868-874.
43. Auerbach SM, Meredith J, Alexander JM, Mercuri LG, Brophy C. Psychological factors in adjustment to orthognathic surgery. Journal of Oral and Maxillofacial Surgery. 1984; 42(7): 435-40.
44. Olson RE, Laskin DM. Expectations of patients from orthognathic surgery. Journal of Oral Surgery. 1980; 38(4): 283-5.

45. Ware J E, Davies-Avery A, Stewart AL. The measurement and meaning of patient satisfaction: a review of the literature. 1977.
46. Cunningham S, Hunt N. Quality of life and its importance in orthodontics. Journal of Orthodontics. 2001; 28: 152-158.
47. Smith A, Cunningham S. Which factors influence willingness-to-pay for orthognathic treatment? European Journal of Orthodontics. 2004; 26: 499-506.
48. Stirling J, Latchford G, Morris D, Kindelan J, Spender R, Bekker H. Elective orthognathic decision-making: a survey of patients reasons and experiences. Journal of Orthodontics. 2007; 34: 113-127.
49. Luther F, Morris D, Karnezi K. Orthodontic treatment following orthognathic surgery: How long does it take and why? A retrospective study. Journal of Oral and Maxillofacial Surgery. 2007; 65: 1969-1976.
50. Green C, Pope C. Gender, psychological factors and the use of medical services: A longitudinal analysis. Social Science & Medicine. 1999; 48: 1363-1372.
51. Bailey L, Haltiwanger L, Blakey G, Proffit W. Who seeks surgical-orthodontic treatment: A current review. The International Journal of Adult Orthodontics & Orthognathic Surgery. 2001; 86: 280-292.
52. Mouakeh M. Cephalometric evaluation of craniofacial pattern of Syrian children with Class III malocclusion. American Journal of Orthodontics and Dentofacial Orthopedics. 2001; 119: 640–649.
53. Foster TD, Day AJ. A survey of malocclusion and the need for orthodontic treatment in a Shropshire school population. British Journal of Orthodontics. 1974;1(3): 73–78.
54. Haynes S. The prevalence of malocclusion in English school children aged 11–12 years. Transactions of the European Orthodontic Society. 1970;: 89–98.
55. Guyer EC, Ellis E, Mcnamara JAJ, Behrents RG. Components of class iii malocclusion in juvenile and adolescents. Angle Orthodontist. 1986; 56: 7–31.
56. Naini FB, Gill DS. Facial aesthetics: 2. clinical assessment. Dental Update. 2008; 35: 159-170.
57. Mandall N, Cousley R, DiBiase A, Dyer F, Littlewood S, Mattick R, Nute S, Doherty B, Stivaros N, McDowall R, Shargill I, Ahmad A, Walsh T, Worthington H. Is early Class III protraction facemask treatment effective? A multicentre, randomized, controlled trial: 3-year follow-up. Journal of Orthodontics. 2012;39(3): 176-85
58. Franchi L, Baccetti T, Tollaro I. Predictive variables for the outcome of early functional treatment of Class III malocclusion. American Journal of Orthodontics and Dentofacial Orthopedics. 1997; 112: 80–86.
59. Baccetti T, Franchi L, McNamara JAJ. Cephalometric variables predicting the long-term success or failure of combined rapid maxillary expansion and facial mask therapy. American Journal of Orthodontics and Dentofacial Orthopedics. 2004; 126: 16–22.
60. Oxford Dictionaries. [Online]. Accessed 16-09-2016. Available from: https://en.oxforddictionaries.com/definition/race#race-2
61. Anemone RL. Race and biological diversity in humans. Race and Human Diversity: A Biocultural Approach. Upper Saddle River, New Jersy: Prentice Hall;2011; 1–10.
62. People J, Bailey G. Humanity: An Introduction to Cultural Anthropology. Belmont: Wadsworth; 2010.
63. Broadbent BH. A new X-ray technique and its application in orthodontics. Angle Orthodontist. 1931; 1: 45–66.
64. Farkas LG. Anthropometry of Head and Face. New York: Raven Press: 1994.
65. Farkas LG, Hreczko TA, Kolar JC, Munro IR. Vertical and horizontal proportions of the face in young adult North American Caucasians: revision of neoclassical norms. Plastic Reconstruction Surgery. 1985; 75: 328-338.
66. Farkas LG, Katic MJ, Hreczko TA, Deutsch C, Munro IR. Anthropometric proportions in the upper lip-lower lip-chin area of the lower face in young white adults. American Journal of Orthodontics. 1984;

86: 52-60.

67. Farkas LG, Katic MJ, Forrest CR, Alt KW, Bagic I I, Baltadjiev G. International anthropometric study of facial morphology in various ethnic groups/races. Journal Craniofacial Surgery. 2005; 16: 615-646.
68. Arnett W, Jelic S, Kim J, Cummings D, Beress E, Worley M. Soft tissue cephalometric analysis: Diagnosis and treatment planning of dentofacial deformity. American Journal of Orthodontics and Dentofacial Orthopedics. 1999; 116: 239-53.
69. Lew KK. Soft tissue cephalometric norms in Chinese adults with aesthetic facial profiles. Journal of Oral and Maxillofacial Surgery. 1992; 50: 1184–1189.
70. Franzoi S, Herzog M. Judging physical attractiveness: what body aspects do we use? Personality and Social Psychology Bulletin. 1987; 13: 19–33.
71. Mueser K, Grau B, Sussman S, Rosen A. You're only as pretty as you feel: facial expression as a determinant of physical attractiveness. Journal of Personality and Social Psychology. 1984; 46: 469–478.
72. Alley T, Hildebrandt K. Determinants and consequences of facial esthetics. In Alley T. Social and Applied Aspects of Perceiving Faces. Hillsdale: Lawrence Erlbaum Associates; 1988: 101–140.
73. Baldwin D. Appearance and aesthetics in oral health. Community Dentistry and Oral Epidemiology. 1980; 8: 244–256.
74. Langlois J, Kalakanis L, Rubenstein A, Larson A, Hallam M, Smoot M. Maxims or myths of beauty? A meta analytic and theoretical review. Psychological Bulletin. 2000; 126: 390–423.
75. Olsen J, Inglehart M. Malocclusions and perceptions of attractiveness, intelligence, and personality, and behavioral intentions. American Journal of Orthodontics and Dentofacial Orthopedics. 2011; 140: 669-79.
76. Martin JG. Racial ethnocentrism and judgment of beauty. Journal of Social Psychology. 1964; 63: 59–63.
77. Cross JF, Cross J. Age, sex and race and the perception of facial beauty. Developmental Psychology. 1971; 5: 433–439.
78. Kiyak HA. Comparison of aesthetic values among Caucasians and Pacific Asians. Community Dentistry and Oral Epidemiology. 1981; 9: 219–223.
79. Mantzikos T. Esthetic soft tissue profile preferences among the Japanese population. American Journal of Orthodontics and Dentofacial Orthopedics. 1998; 114: 1-7.
80. Mandall NA, McCord JF, Blinkhorn AS, Worthington HV, O'Brian KD. Perceived aesthetic impact of malocclusion and oral self-perceptions in 14–15-year-old Asian and Caucasian children in Greater Manchester. European Journal of Orthodontics. 1999; 21: 175–183.
81. Naini FB, Donaldson A, McDonald F, Cobourne M. Assessing the influence of chin prominence on perceived attractiveness in the orthognathic patient, clinician and layperson. International Journal of Oral and Maxillofacial Surgery. 2012; 41: 839–846.
82. Naini FB, Donaldson A, Cobourne M, McDonald F. Assessing the influence of mandibular prominence on perceived attractiveness in the orthognathic patient, clinician, and layperson. European Journal of Orthodontics. 2012;: 738–746.
83. Naini FB, Donaldson A, McDonald F, Cobourne M. Assessing the influence of lower facial profile convexity on perceived attractiveness in the orthognathic patient, clinician, and layperson. Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontology. 2012; 114: 303-311.
84. Almeida MD, Bittencourt MAV. Anteroposterior Position of Mandible and Perceived Need for Orthognathic Surgery. Journal of Oral and Maxillofacial Surgery. 2009; 67: 73-82.
85. Pithon MM, Silva ISN, Almeida IO, Nery MS, Souza ML, Barbosa G. Photos vs silhouettes for evaluation of profile esthetics between white and black evaluators. Angle Orthodontist. 2014; 84: 231–238.

86. Evalued. [Online]; Accessed 16-09-2016. Available from: http://www.evalued.bcu.ac.uk/tutorial/4a.htm
87. Snap survey. [Online]; Accessed 16-09-2016. Available from: http://www.snapsurveys.com/blog/25-ways-increase-survey-response-rates/
88. McMahon SR, Iwamoto M, Massoudi MS, Yusuf HR, Stevenson JM, David F. Comparison of e-mail, fax, and postal surveys of pediatricians. Pediatrics. 2003 Apr; 111: 299-303.
89. Nulty DD. The adequacy of response rate to online and paper surveys: what can be done?. Assessment & Evaluation in Higher Education. 2008 June; 33: 301-314.
90. Scott A, Jeon SH, Joyce CM, Humphreys JS, Kalb G, Witt J. A randomised trial and economic evaluation of the effect of response mode on response rate, response bias, and item non-response in a survey of doctors. BMC Medical Research Methodology. 2011 Nov; 126.
91. Crawford S, McCabe SE, Pope D. Applying web-based survey design standards. Journal of Prevention and Intervention in the Community. 2005; 29: 43-66.
92. Edwards P, Roberts I, Clarke M, DiGuiseppi C, Pratap S, Wentz R. Increasing response rates to postal questionnaires: systematic review. British Medical Journal. 2002; 324(7347): 1183-1185.
93. Naini F, Cobourne M, McDonald F, Wertheim D. Aesthetic impact of the upper component of the nasolabial angle: A quantitative investigation. Journal of Oral and Maxillofacial Surgery, Medicine, and Pathology. 2015 July;27 (4): 470-476.
94. Cooke M, Wei S. The reproducibility of natural head posture: a methodological study.. American Journal of Orthodontic and Dentofacial Orthopedics. 1988; 93: 280-288.
95. Random Name Picker. [Online]; Accessed 16-09-2016. Available from http://www.miniwebtool.com/random-name-picker/
96. List Randomizer. [Online]; Accessed 16-09-2016. Available from: https://www.random.org/lists/
97. Landis J, Koch G. The measurement of observer agreement for categorical data. Biometrics. 1977; 33: 159-174.
98. Maple J, Vig K, Beck F, Larsen P, Shanker S. A comparison of providers' and consumers' perceptions of facial-profile attractiveness. American Journal of Orthodontics and Dentofacial Orthopedics. 2005; 128(6): 690-96.
99. Arpino V, Giddon D, Begole E. Presurgical profile preferences of patients and clinicians. American Journal of Orthodontic Dentofacial Orthopedics. 1998;114: 631.
100. Hodge TM, Boyd PT, Munyombwe, T, Littlewood SJ. Orthodontists' perceptions of the need for orthognathic surgery in patients with Class II Division 1 malocclusion based on extraoral examinations. American Journal of Orthodontics and Dentofacial Orthopedics. 2012; 142: 52-9.
101. Naini, F. Silhouettes study. Email communication (30-09-2014)
102. Reid B. Perception of facial attractivness: outcomes of orthognathic surgery. 2015. Unpublished thesis.
103. Bernstein IH, Lin TD, McClellan P. Cross- vs. within-racial judgments of attractiveness. Perception and Psychophysics. 1982; 32: 495-503.
104. Johnston C , Hunt O , Burden D , Stevenson M , Hepper P. The influence of mandibular prominence on facial attractiveness . European Journal of Orthodontics 2005;27: 129 ‑ 133.
105. Xu YM, Korn EL, Liu Y, Oh HS, Lee KH, Boyd BL, Baumrind S. Facial attractiveness: Ranking of end-of-treatment facial photographs by pairs of Chinese and US orthodontists. American Journal of Orthodontics and Dentofacial Orthopedics 2008;134: 74-84
106. Burke F, Tan R. Response rates to questionnaires mailed to dentists: a review of 77 publications. International Dental Journal. 1997; 47: 349-354.

107. Impellizzeri F, Maffiuletti N. Convergent evidence for construct validity of a 7-point likert scale of lower limb muscle soreness. Clinical Journal of Sport Medicine. 2007;17(6): 494-6.
108. Meyer DE., Schvaneveldt RW. Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. Journal of Experimental Psychology. 1971;90: 227–234
109. Guise V, Chambers M, Välimäki M, Makkonen P. A mixed-mode approach to data collection: combining web and paper questionnaires to examine nurses' attitudes to mental illness. Journal of Advanced Nursing. 2010; 66(7): 1623-32.
110. Shaefer DR, Dillman DA. Development of a standard email methodology: Results of an experiment. Public Opinion Quarterly. 1998; 62: 378-397.
111. Shelly AM, Brunton P, Horner K. Questionnaire surveys of dentists on radiology. Dentomaxillofacial Radiology. 2012; 41: 267–275.
112. Jepson C, Asch DA, Hershey JC, Ubel PA. In a mailed physician survey, questionnaire length had a threshold effect on response rate. Journal of Clinical Epidemiology. 2005; 58: 103–105.
113. Groves RM, Singer E, Corning AD, Bower. A laboratory approach to measuring the effects on survey participation in interview length, incentives, differential incentives, and refusal conversion. Journal of Official Statistics. 1999 Feb; 15: 251–268.
114. Heberlein TA, Baumgartner R. Factors affecting response rates to mailed questionnaires: A quantitative analysis of the published literature. American Sociological Review. 1978; 43: 447–462.
115. Steele TJ, Schwendig WL, Kilpatrick J. A. Duplicate responses to multiple survey mailings: A problem? Journal of Advertising Research. 1992 Feb; 32: 26–34.
116. Yammarino FL, Skinner SJ, Childers TL. Understanding mail survey response behavior: a meta-analysis. Public Opinion Quarterly. 1991 Apr; 55: 613–639.
117. Griffith LE, Cook DJ, Guyatt GH, Charles C. Comparison of Open and Closed Questionnaire Formats in Obtaining Demographic Information from Canadian General Internists. Journal of Clinical Epidemiology. 1999 Oct; 52: 997-1005.
118. Flanigan TS, McFarlane E, Cook S. Conducting Survey Research among Physicians and Other Medical Professionals—A Review of Current Literature. Proceedings of the Survey Research Methods Section, American Statistical Association, 2008; 4136–47.
119. Karatas OH, Toy E. Three-dimensional imaging techniques: A literature review. European Journal of Dentistry. 2014; 8(1): 132–140.

9 Appendices

9.1 Caucasian soft tissue norms

Figure 9.1.1: Caucasian adult male profile based on Farkas *et al.* [67]

Table 9.1.1: Facial soft tissue anthropometric landmarks definition based on Farkas *et al.* [64] [65] [66] [67]

Soft tissue anthropometric landmarks	Definition
Trichion (tr)	The most superior point on the forehead at the junction with the hairline.
Soft tissue glabella (g')	The most prominent point between the eyebrows in the midsagittal plane of the forehead.
Soft tissue nasion (n')	The point of greatest concavity in the midline between the forehead and the nose.
Soft tissue menton (me')	The lowest median landmark on the lower border of the mandible.
Subnasale (sn)	The point located at the base of the nose.
Zygion (zy)	The most lateral point of each zygomatic arch.
Cheilion (ch)	The point in the junction between the upper and lower lips.
Alare (al)	The most lateral point of the lateral contour of the ala of the nose.
Exocanthion (ex)	The most lateral point at the junction between the upper and lower eyelids.
Endocanthion (en)	The medial point at the junction between the upper and lower eyelids.

Table 9.1.2: Soft tissue measurements for Caucasian males and females by Farkas *et al* [64] [65] [66] [67]

Measurement	Caucasian male	Caucasian female
Sample size	109	109
Head		
tr-n	70.1 mm	63.3 mm
Inclination of forehead	-9.8°	-5.9°
Face		
tr-g	57 mm	52.7 mm
n-gn	124.7 mm	111.4 mm
n-sto	76.4 mm	69.4 mm
sto-gn	50.7 mm	43.4 mm
sn-gn	72.6 mm	64.3 mm
zy-zy	144.6 mm	136.2 mm
go-go	107.3 mm	102.3 mm
Orbits		
en-en	37.6 mm	36.1 mm
en-ex	29.4 mm	28.4 mm
ex-ex	91.7 mm	87.3 mm
Nose		
n-sn	53.0 mm	48.9 mm
al-al	34.7 mm	31.4 mm
nasal bridge inclination	30.4 $\pm$ 3.6°	29.9 $\pm$ 3.9°
nasio-labial angle	99.8 $\pm$ 11.8°	104.2 + 9.8°
nasio-frontal angle	130.3 $\pm$ 7.4°	134.3 $\pm$ 7°
Labio-oral region		
ch-ch	53.3 mm	49.8 mm
Ear		
sa-sba	62.4 mm	58.5 mm

9.2 Chinese soft tissue norms

Table 9.2.1: Soft tissue measurements for Chinese males and females by Farkas *et al* [67]

Measurement	Chinese Male	Chinese Female
Sample size	30	30
Head		
tr-n	67.1 mm	64.1 mm
Inclination of forehead	-13.7°	-9.2°
Face		
tr-gn	187.3 mm	176.2 mm
n-gn	123.6 mm	114.9 mm
n-sto	78.2 mm	71.8 mm
sto-gn	53.4 mm	47.2 mm
sn-gn	72.8 mm	66.4 mm
zy-zy	144.6 mm	136.2 mm
go-go	107.3 mm	102.3 mm
Orbits		
en-en	37.6 mm	36.1 mm
en-ex	29.4 mm	28.4 mm
ex-ex	91.7 mm	87.3 mm
Nose		
n-sn	43.8 mm	51.7 mm
al-al	39.2 mm	37.2 mm
nasal bridge inclination	27.2 $\pm$ 3.5°	24.5 $\pm$ 3.6°
nasio-labial angle	86.9 $\pm$ 12.2°	88.5 + 11.2°
nasio-frontal angle	134.5 $\pm$ 7°	135.6 $\pm$ 4.4°
Labio-oral region		
ch-ch	49.6 mm	47.3 mm
Ear		
sa-sba	60.7 mm	57.6 mm

9.3 Systematic electronic search

Table 9.3.1: Search terms used 28-6-14 in Google scholar, Medline and EBSCO

Population	Interest	Context
Racial Race Ethnic* Racial/Ethnic Ethnic/Racial Chinese* Caucasian* African* Oriental* Asian* Black* White* Hispanic*	aesthetic esthetic appearance attractive* perceived need perceived benefit perceived aesthetic self-perception self-perceived self-awareness perception soft tissue profile profile* facial face* differen* disparit*	orthod* dental dentofacial fixed appliance* removable appliance* dental brace* occlusion* occlusal malocclusion* cephalometric*

9.4 Ethical approval for this study

Dr Nora Flannigan
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17th March 2015

Dear Dr Flannigan

I am pleased to inform you that the ILT Ethics Review Group (staff) has approved your application for ethical approval. Details of the approval can be found below:

Ref: 201502189
Title of the Research: Clinicans' Perception of the need for Orthognathic Surgery (is a surgery to correct the condition of the jaw or face related to structures) in Patients of Different Racial Background Presenting with Class 3 Skeletal Discrepancy (class 3 is a skeletal disharmony patients present with small upper jaw or big lower jaw)
PI: Dr Norah Flannigan
Title: Senior Clinical Lecturer
Student Investigator: Dalal Alrashidi
School: Orthodontic/Dentistry
First Reviewer: Trish Owen
Second Reviewer: Ben Shaw
Date of Initial Review: 04/03/15
Date of Approval: 11/03/15

This approval applies for the duration of the research. If it is proposed to extend the duration of the study as specified in the application form, the ILT Ethics Review Group (staff) should be notified. If it is proposed to make an amendment to the research, you should notify the ILT Ethics Review Group (staff) by the Notice of Amendment procedure. If the PI/Supervisor leaves the employment of the University during the course of this approval, the approval will lapse. Therefore please contact the RGO at ethics@liverpool.ac.uk in order to notify them of a change in PI/Supervisor.

Best wishes and good luck with the study.

Jennie Jebb

Jennie Jebb
ILT Ethics Review Group (Staff) Secretary

E: jjebb@liv.ac.uk
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CC: Dala Alrashidi

9.5 Invitation letter (web-based version)

Department of Orthodontics
Liverpool University Dental Hospital and School of Dentistry
Pembroke Place, Liverpool
L3 5PS

Invitation letter

Dear Consultant,

I would like to invite you to participate in a questionnaire about "The perception of benefit from orthognathic surgery". It includes silhouettes of patients of different racial groups (Caucasian and Chinese). The questionnaire asks you to spend no more than 30 seconds looking at each silhouette and then answer the following questions: 1) "Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?"; and 2) How do you rate the level of attractiveness of this profile?

The questionnaire is anonymous although a code will be used to allow us to send reminders to those who have not responded. The codes will be kept by the research team for this purpose alone, and will be destroyed once the data are collected. I greatly appreciate your help with this investigation. By reading this letter, and completing this questionnaire, you are consenting to participate in this study.

Kindest regards,

Dr. N.L. Flannigan
Senior Clinical Lecturer/
Hon Consultant in Orthodontics
Liverpool University Dental Hospital

9.6 Invitation letter (Paper version)

National Orthognathic Surgery Survey

Invitation letter

Dear Consultant,

I would like to invite you to participate in a questionnaire about the "Perception of Benefit from Orthognathic Surgery" which is a part of research dissertation associated with the DDSc programme at the University of Liverpool. This study includes computer-manipulated silhouettes of patients of different racial groups (Caucasian and Chinese).

I will kindly ask you to spend no more than 30 seconds looking at each silhouette and then answer the following question:

"Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?"

I understand that in a real-life clinical scenario, the decision for surgery would be based on a wide range of records, but for the purposes of this study a distinct yes or no answer will be required.

The questionnaire is anonymous but a code is used to allow us to follow up those who have not responded. The codes will be kept by the research team for follow up purposes only, and this will be destroyed once the data are collected.

By reading this letter, and completing the questionnaire, you are consenting to participate in this study. A paper copy will be sent within the next 6 weeks, if you would like to fill in the questionnaire online and do not want us to provide you with a paper copy, then please tick the following box and send back to me:

☐ I would like to fill the questionnaire online

☐ I would like to receive a paper copy of the questionnaire

☐ I do not wish to take part in the questionnaire

We greatly appreciate your help with this study.

Kindest regards,

Dr. N.L. Flannigan

Senior Clinical Lecturer/Hon Consultant in Orthodontics

Liverpool University Dental Hospital and School of Dentistry

Pembroke Place, Liverpool

L3 5PS

9.7 Reminder letter (Paper version)

UNIVERSITY OF LIVERPOOL

BAOMS British Association of Oral and Maxillofacial Surgeons

BOS BRITISH ORTHODONTIC SOCIETY Registered Charity No. 1073464

National Orthognathic Surgery Survey

Reminder letter

Dear Consultant,

Thank you very much for requesting a paper copy to participate in a questionnaire about the "Perception of Benefit from Orthognathic Surgery" which is a part of research dissertation associated with the DDSc programme at the University of Liverpool. This study includes computer-manipulated silhouettes of patients of different racial groups (Caucasian and Chinese).

I will kindly ask you to spend no more than 30 seconds looking at each silhouette and then answer the following question:

"Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?"

I understand that in a real-life clinical scenario, the decision for surgery would be based on a wide range of records, but for the purposes of this study a distinct yes or no answer will be required.

The questionnaire is anonymous but a code is used to allow us to follow up those who have not responded. The codes will be kept by the research team for follow up purposes only, and this will be destroyed once the data are collected. Please choose one of the following options:

☐ I would like to fill the questionnaire online (sent by Ann Wright on 03.06.2015)

☐ I will complete a paper copy of the questionnaire (enclosed)

If you wish to be removed from the mailing list, please tick the following box and send back to me:

☐ I have already filled the questionnaire online

☐ I do not wish to take part in the questionnaire

We greatly appreciate your help with this study.

Kindest regards,

Dr. N.L. Flannigan

Senior Clinical Lecturer/Hon Consultant in Orthodontics

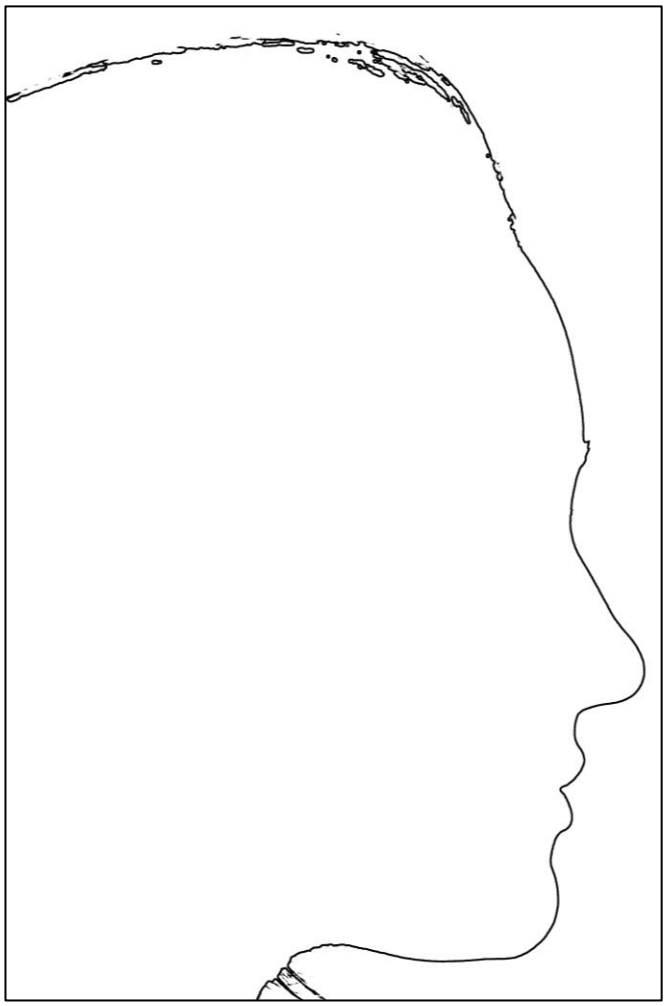
Liverpool University Dental Hospital and School of Dentistry

Pembroke Place, Liverpool

L3 5PS

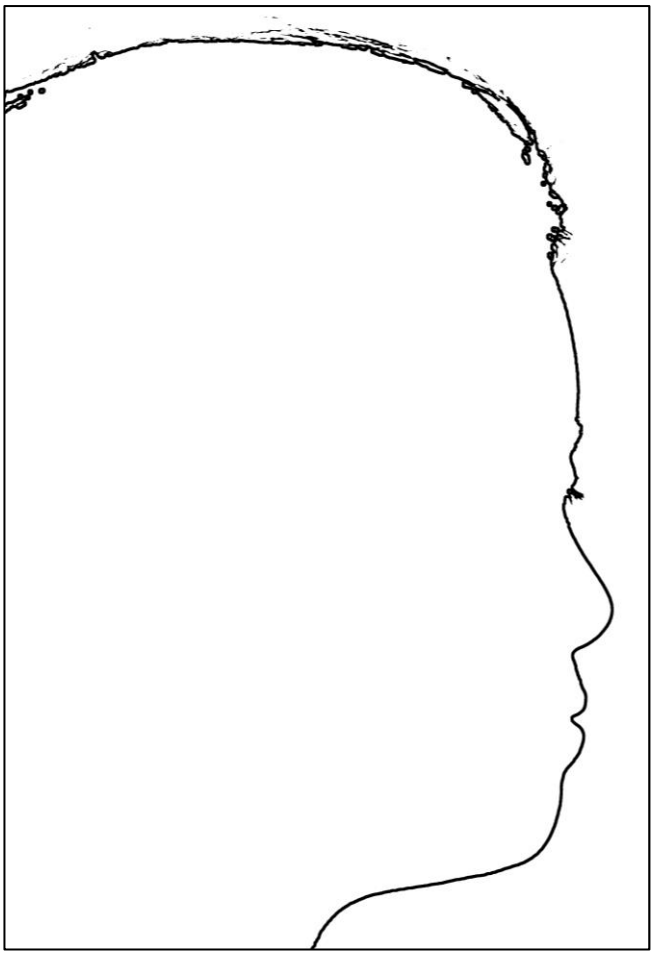
9.8 Caucasian patient profile

Figure 9.8.1: The profile view of the Caucasian patient selected for the study



9.9 Chinese patient profile

Figure 9.9.1: The profile view of the Caucasian patient selected for the study



9.10 List of silhouettes codes

Double letters were assigned to every silhouette to be easily identified and referred to it in the study. These codes are listed in table 9.9.1 and 9.9.2.

Table 9.10.1: Caucasian silhouettes codes used in the questionnaire.

Caucasian Silhouette code	Silhouette size
AS	Maxilla moved posteriorly by 2 mm
MF	Maxilla moved posteriorly by 4 mm
LR	Maxilla moved posteriorly by 6 mm
MH	Maxilla moved posteriorly by 8 mm
SM	Maxilla moved posteriorly by 10 mm
FS	0 mm
AM	Mandible moved anteriorly 2 mm
EW	Mandible moved anteriorly 4 mm
RS	Mandible moved anteriorly 6 mm
MA	Mandible moved anteriorly 8 mm
NS	Mandible moved anteriorly 10 mm

Table 9.10.2: Chinese silhouettes codes used in the questionnaire

Chinese Silhouette code	Silhouette size
SR	Maxilla moved posteriorly by 2 mm
GR	Maxilla moved posteriorly by 4 mm
MT	Maxilla moved posteriorly by 6 mm
SH	Maxilla moved posteriorly by 8 mm
SC	Maxilla moved posteriorly by 10 mm
FM	0 mm
DC	Mandible moved anteriorly 2 mm
DG	Mandible moved anteriorly +4 mm
CD	Mandible moved anteriorly 6 mm
MS	Mandible moved anteriorly 8 mm
ZA	Mandible moved anteriorly 10 mm

9.11 List of random order of the silhouettes in the questionnaires

The random order that was generated for Caucasian and Chinese silhouettes using a website called List randomizer [96] listed in table 9.13.1 and 9.13.2.

Table 9.11.1: Caucasian silhouettes order used in the questionnaire.

No.	Caucasian Silhouette code order	Manipulation size
1	LR	Maxilla moved posteriorly by 6 mm
2	MH	Maxilla moved posteriorly by 8 mm
3	NS	Mandible moved anteriorly by 10 mm
4	SM	Maxilla moved posteriorly by10 mm
5	MH duplicate	Maxilla moved posteriorly by 8 mm
6	RS	Mandible moved anteriorly by 6 mm
7	MF	Maxilla moved posteriorly by 4 mm
8	EW	Mandible moved anteriorly by 4 mm
9	AS	Maxilla moved posteriorly by 2 mm
10	MA	Mandible moved anteriorly by 8 mm
11	RS duplicate	Mandible moved anteriorly by 6 mm
12	FS	Silhouette without manipulation (0 mm)
13	AM	Mandible moved anteriorly by 2 mm

Table 9.11.2: Chinese silhouettes order used in the questionnaire.

No.	Chinese Silhouette code	Manipulation size
1	ZA	Mandible moved anteriorly by 10 mm
2	GR	Maxilla moved posteriorly by 4 mm
3	SC	Maxilla moved posteriorly by 10 mm
4	ZA duplicate	Mandible moved anteriorly by 10 mm
5	MS	Mandible moved anteriorly by 8 mm
6	CD	Mandible moved anteriorly by 6 mm
7	SR	Maxilla moved posteriorly by 2 mm
8	GR duplicate	Maxilla moved posteriorly by 4 mm
9	FM	Silhouette without manipulation (0 mm)
10	MT	Maxilla moved posteriorly by 6 mm
11	SH	Maxilla moved posteriorly by 8 mm
12	DG	Mandible moved anteriorly by 4 mm
13	DC	Mandible moved anteriorly by 2 mm

9.12 The questionnaire

Please complete all sections below:

Section I: About yourself

- How old are you?

  ☐

- What is your gender?
  - Male
  - Female
- What is your ethnicity?
  - White British
  - White Irish
  - Asian Indian
  - Others (Please specify:……..
  - Asian Pakistani
  - Asian Bangladeshi
  - Asian Chinese
  - Black African
  - Black Caribbean
- How important do you think it is to have an attractive facial appearance?

Extremely important	Very important	Slightly important	Neither important nor unimportant	Slightly unimportant	Very unimportant	Extremely unimportant
☐	☐	☐	☐	☐	☐	☐

Section II: About your current profession

- Specialty:
    - Consultant orthodontists
    - Consultant oral and maxillofacial surgeon
- Which UK Region do you work in predominantly?

○ Eastern	○ Oxford Group	○ Trent
○ London	○ Scotland	○ Wales
○ Mersey	○ South East	○ Wessex
○ North Wales	○ South West	○ West Midlands
○ Northern	○ South West Thames	○ Yorkshire
○ Northern Ireland		
○ Others (Please specify:……..		

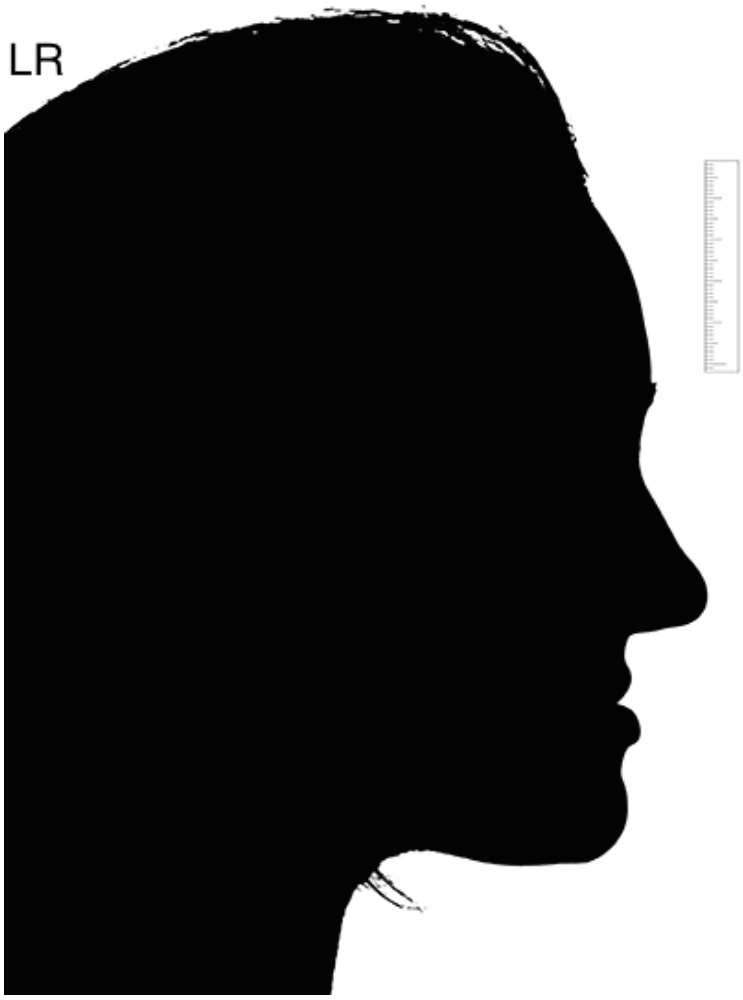
- How many years have you been a consultant?

  ☐

- How many orthognathic patients you treat each year?

○ 0 to 5	○ 16 to 20	○ more than 30
○ 6 to 10	○ 21 to 25	
○ 11 to 15	○ 26 to 30	

Section IV: Please complete all the questions below

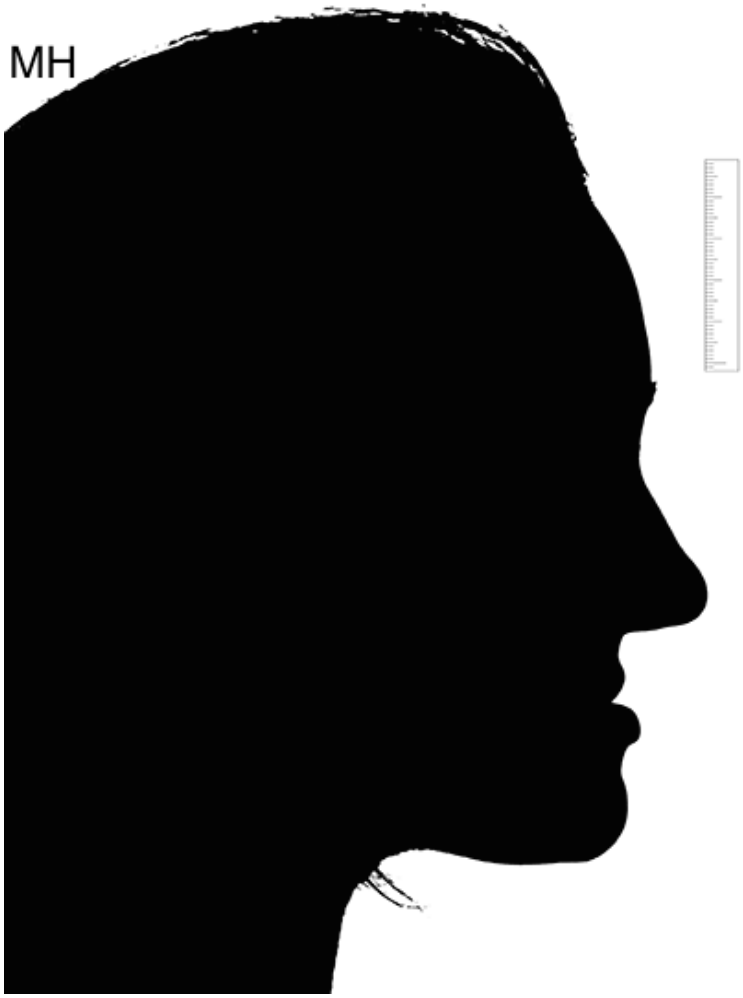


Silhouette of an adult Caucasian female

- Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?
    - Yes
    - No

- How do you rate the level of attractiveness of this profile?

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
☐	☐	☐	☐	☐	☐	☐

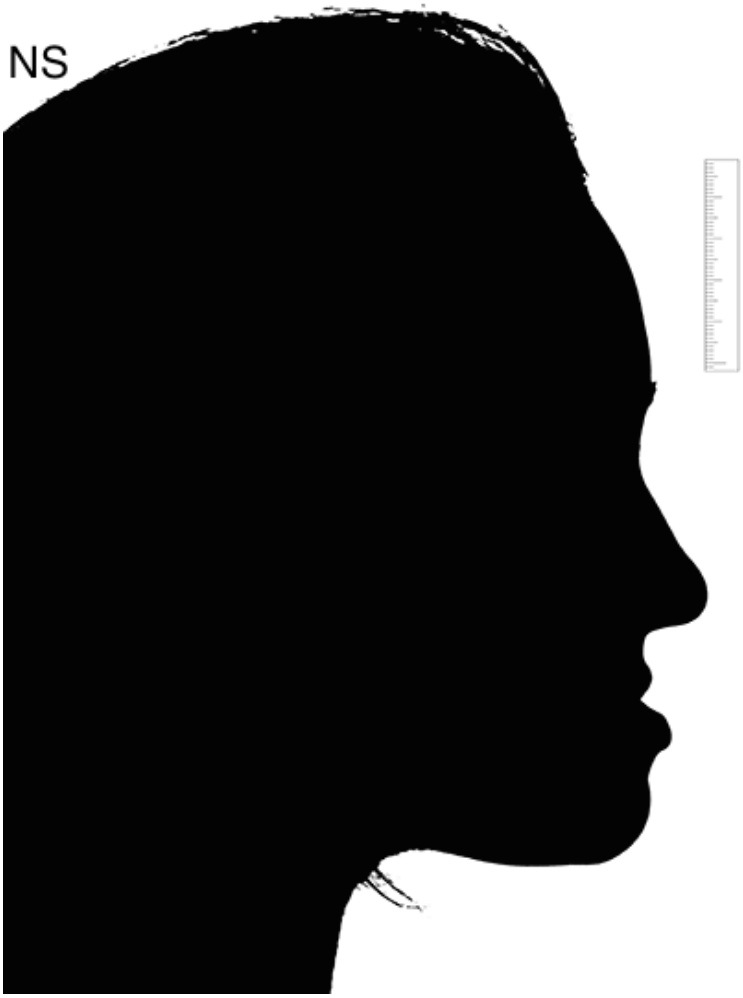


Silhouette of an adult Caucasian female

- Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?
    - Yes
    - No

- How do you rate the level of attractiveness of this profile?

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
☐	☐	☐	☐	☐	☐	☐



Silhouette of an adult Caucasian female

- Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?
    - Yes
    - No

- How do you rate the level of attractiveness of this profile?

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
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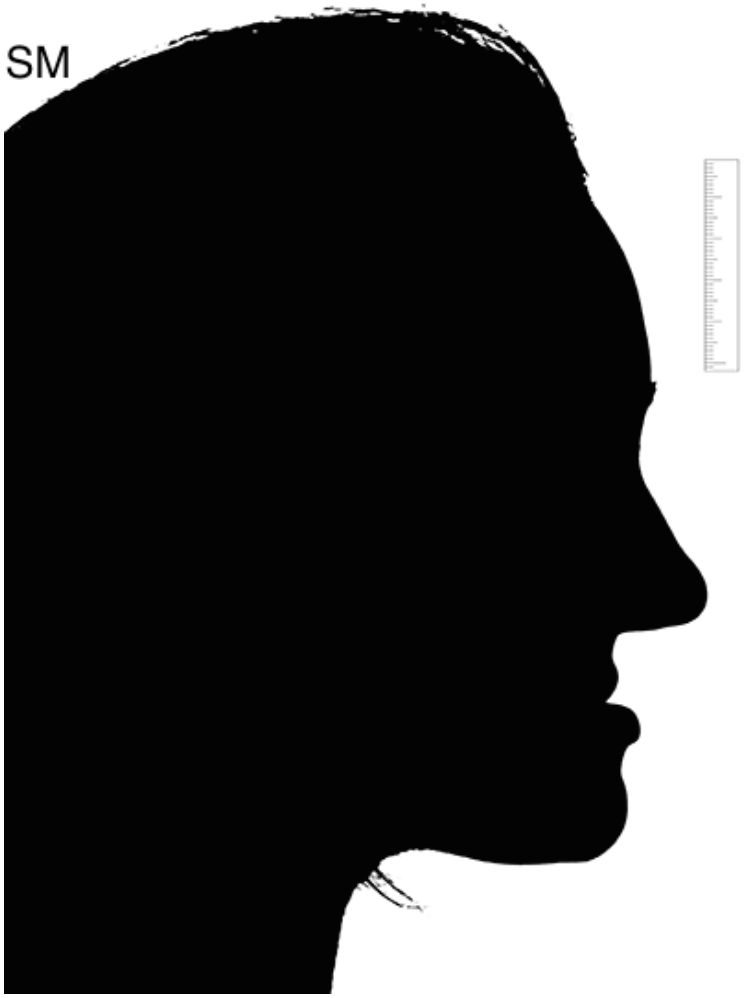

Silhouette of an adult Caucasian female

- Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?
    - Yes
    - No

- How do you rate the level of attractiveness of this profile?

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
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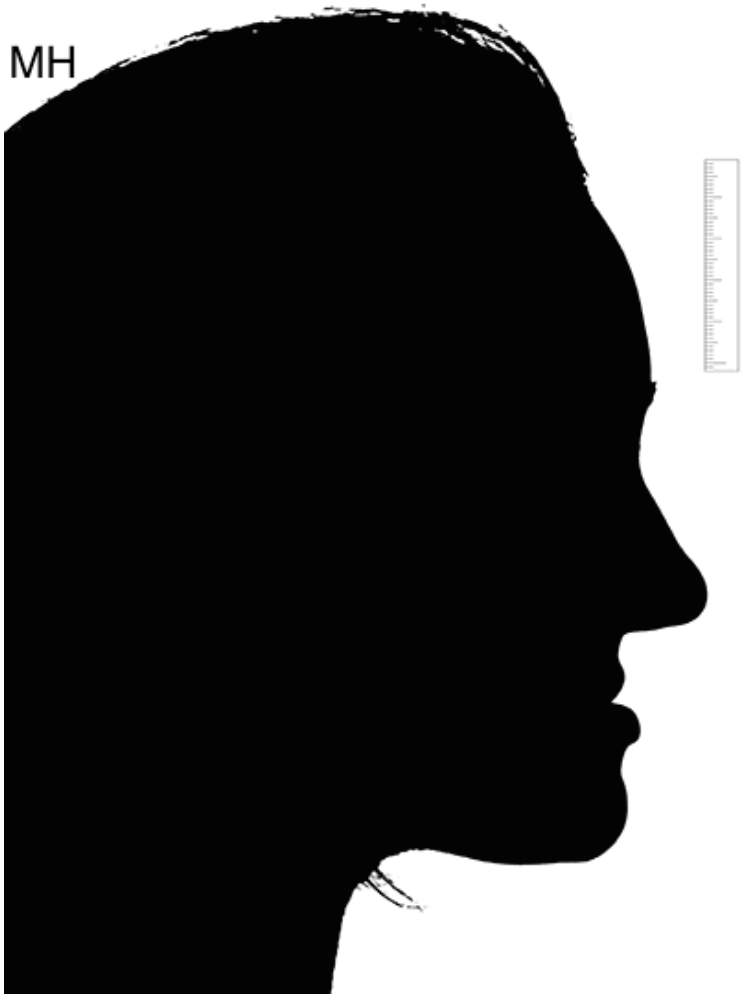

Silhouette of an adult Caucasian female

- Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?
    - Yes
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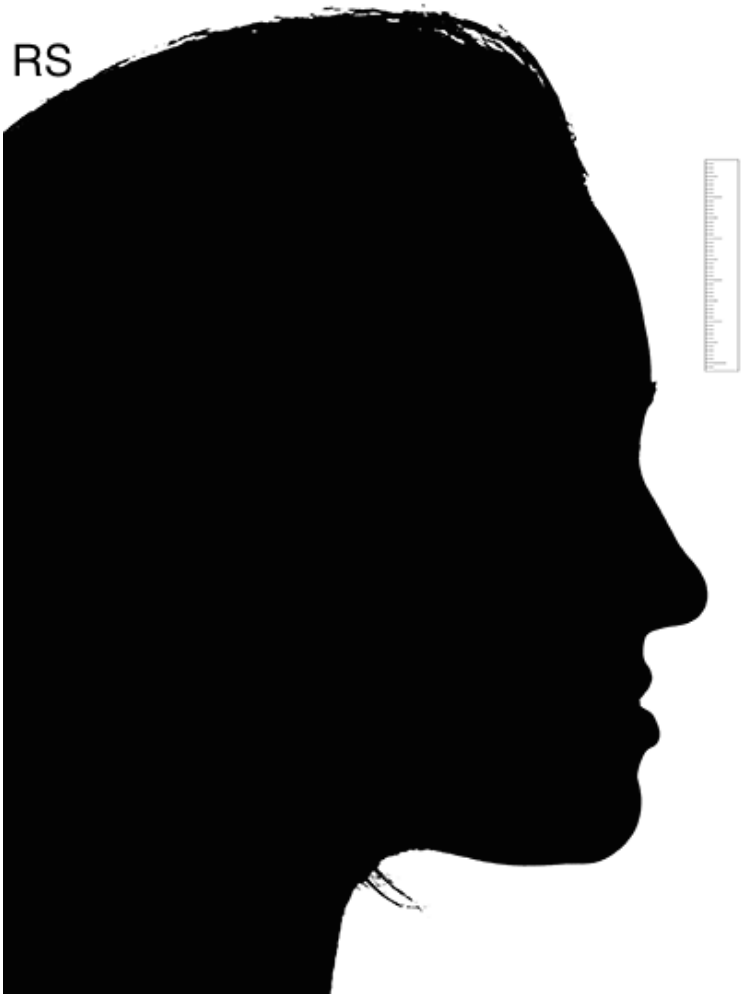

Silhouette of an adult Caucasian female

- Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?
    - Yes
    - No

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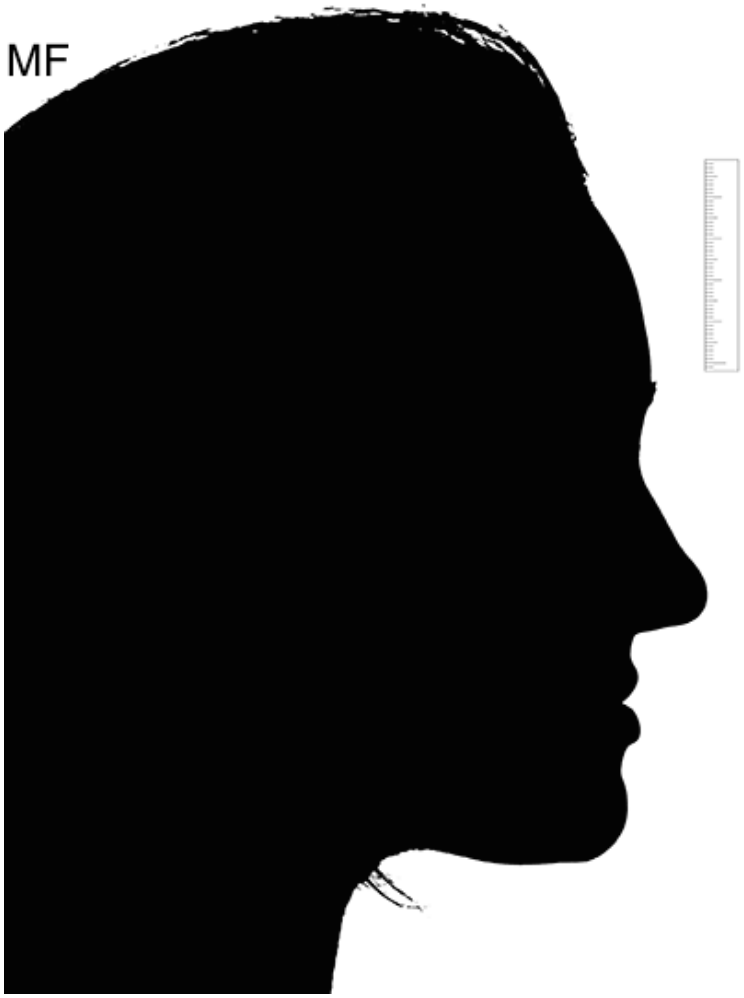

Silhouette of an adult Caucasian female

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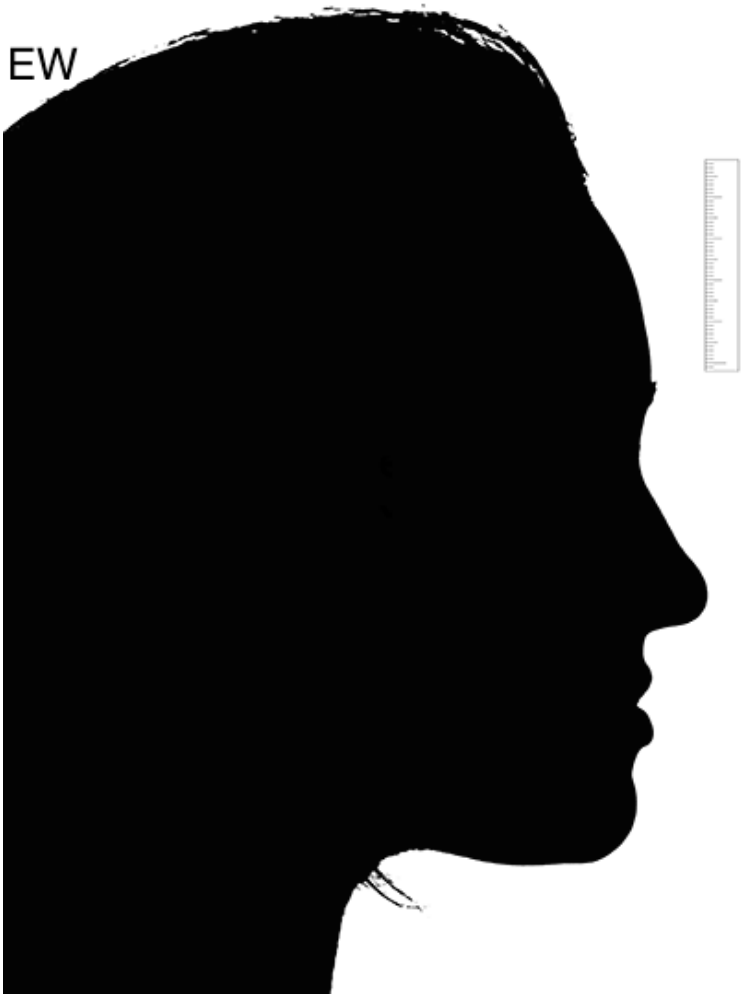

Silhouette of an adult Caucasian female

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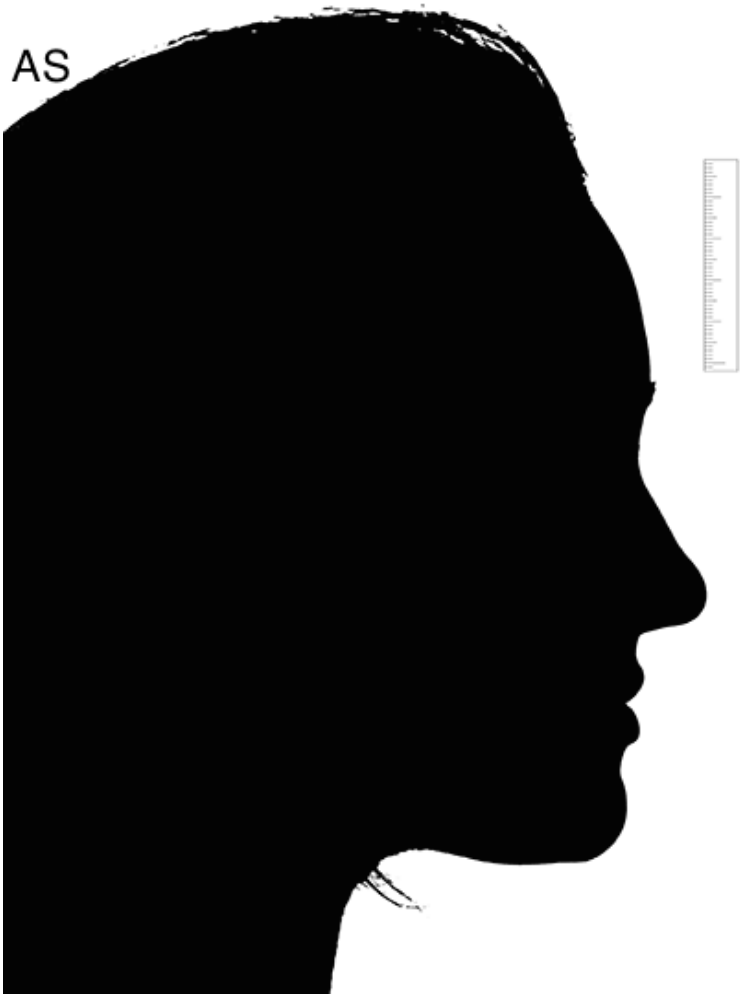

Silhouette of an adult Caucasian female

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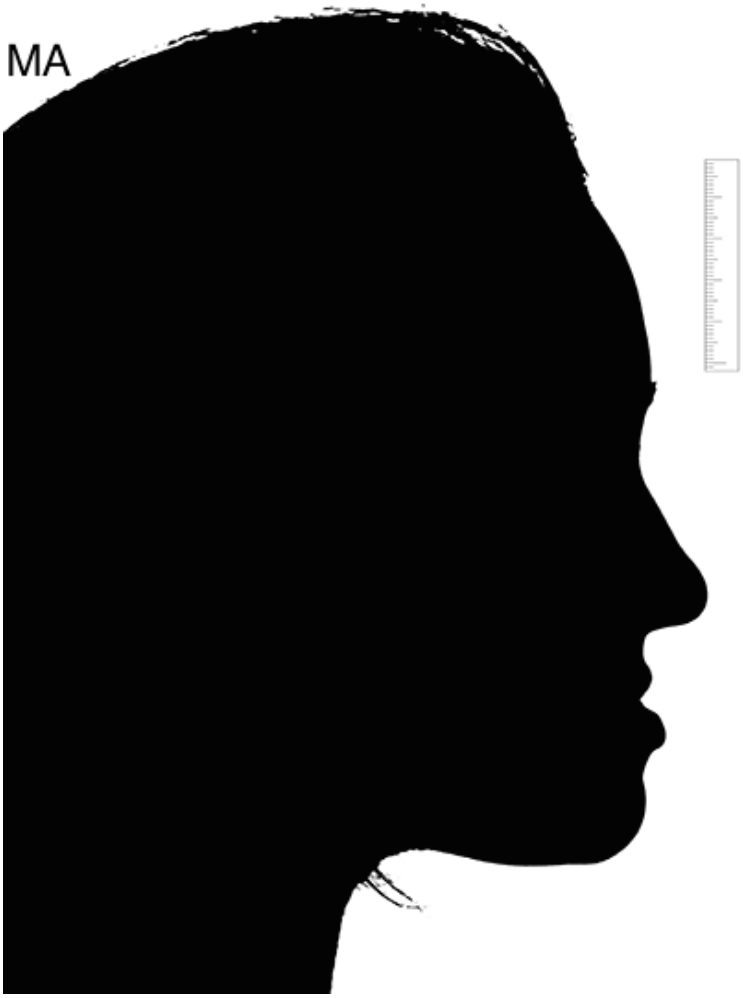

Silhouette of an adult Caucasian female

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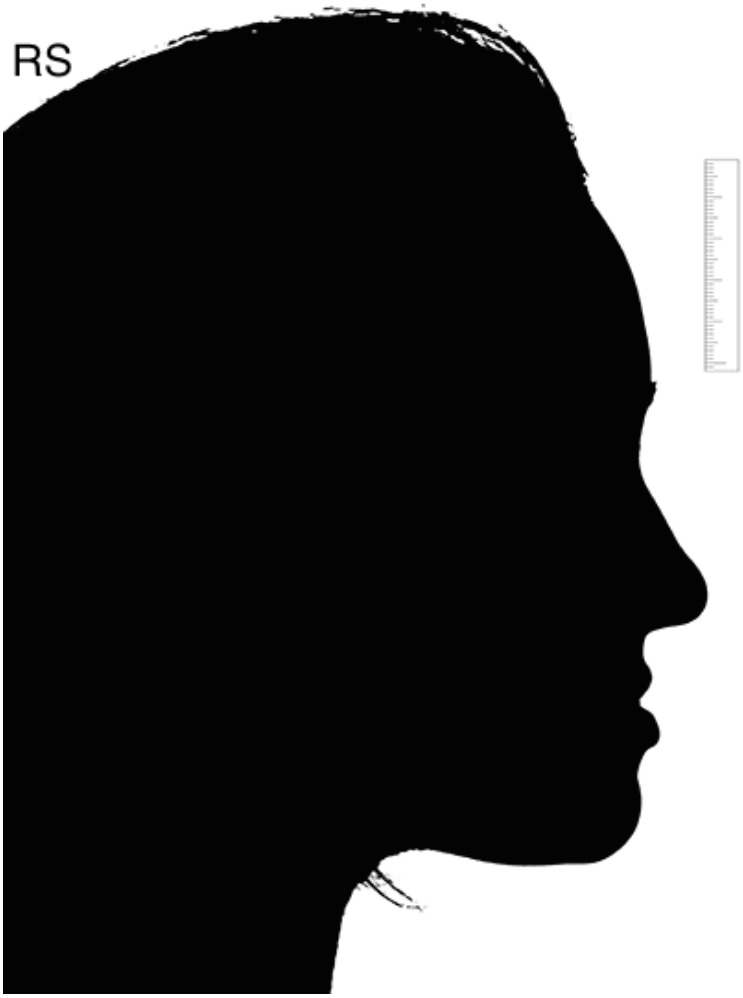

Silhouette of an adult Caucasian female

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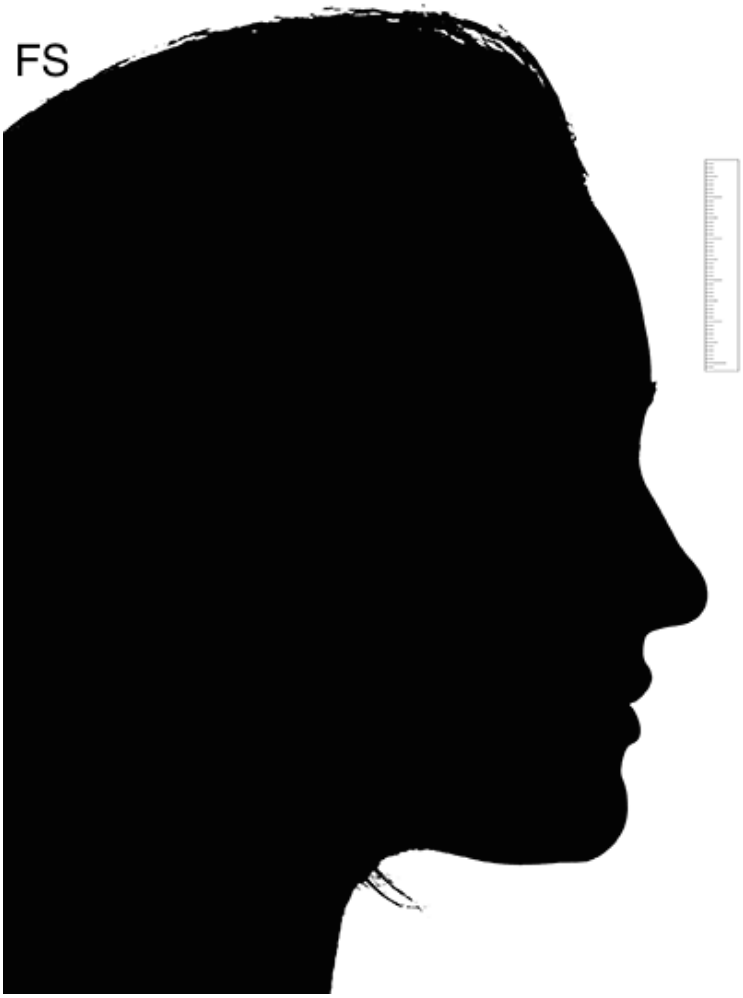

Silhouette of an adult Caucasian female

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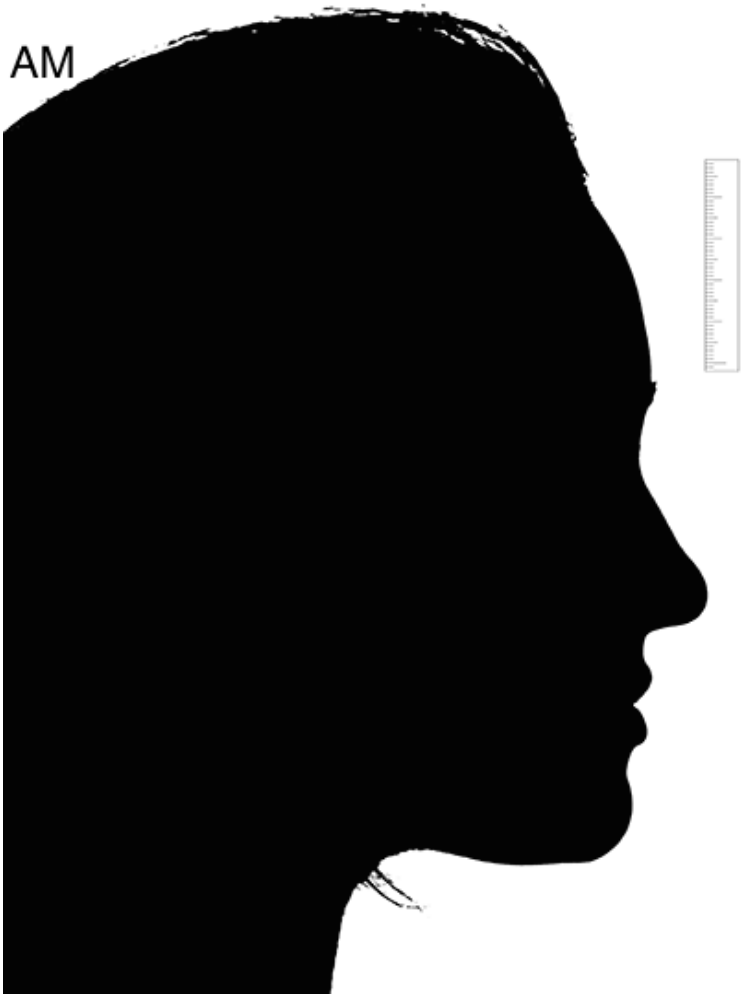

Silhouette of an adult Caucasian female

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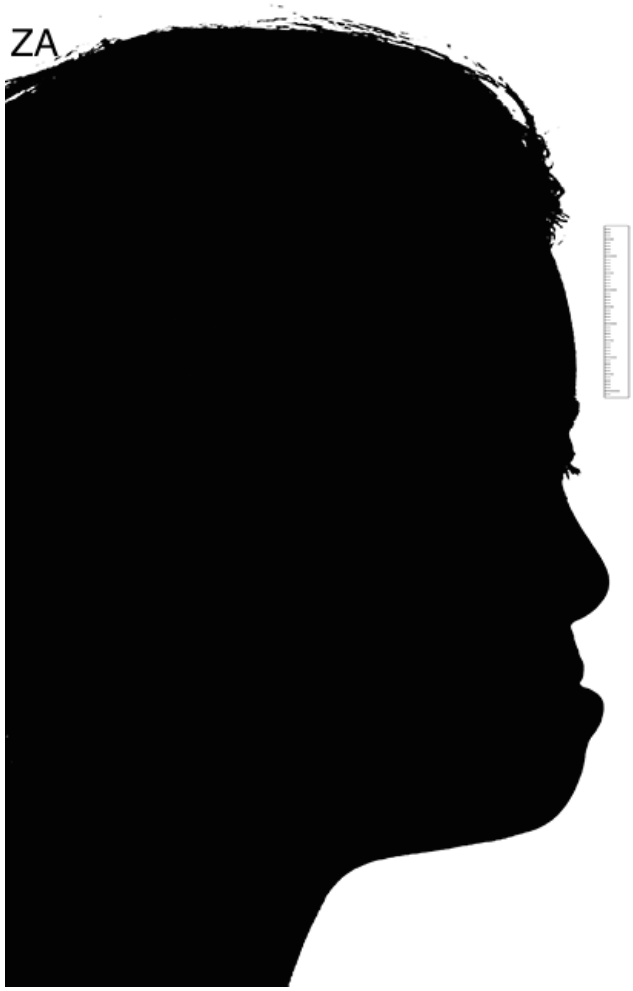
    - Yes
    - No

- How do you rate the level of attractiveness of this profile?

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
☐	☐	☐	☐	☐	☐	☐

Section V: Please complete all the questions below

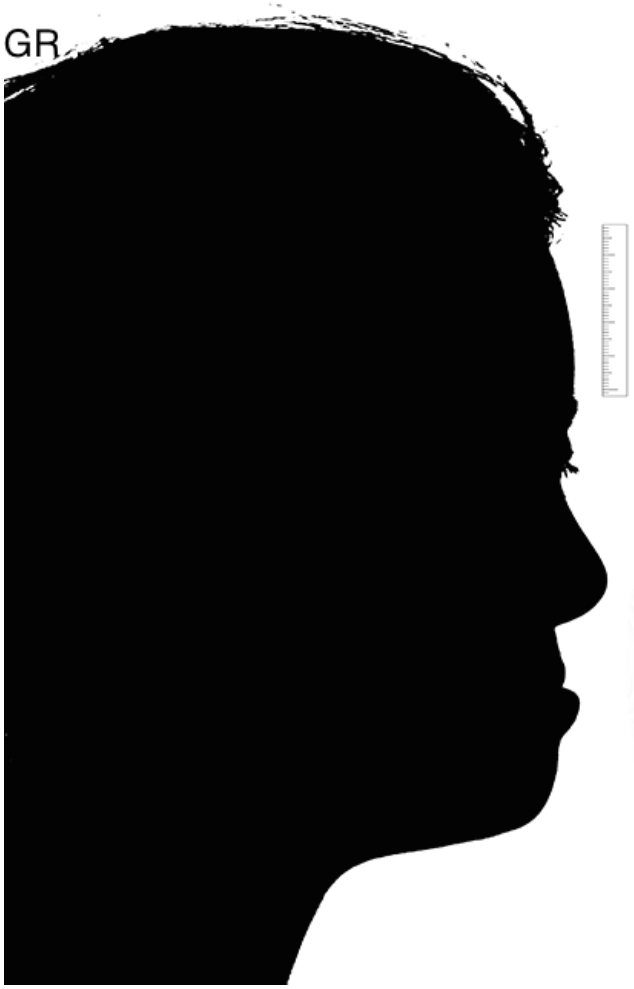


Silhouette of an adult Chinese female

- Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?
    - Yes
    - No

- How do you rate the level of attractiveness of this profile?

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
☐	☐	☐	☐	☐	☐	☐



Silhouette of an adult Chinese female

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    - Yes
    - No

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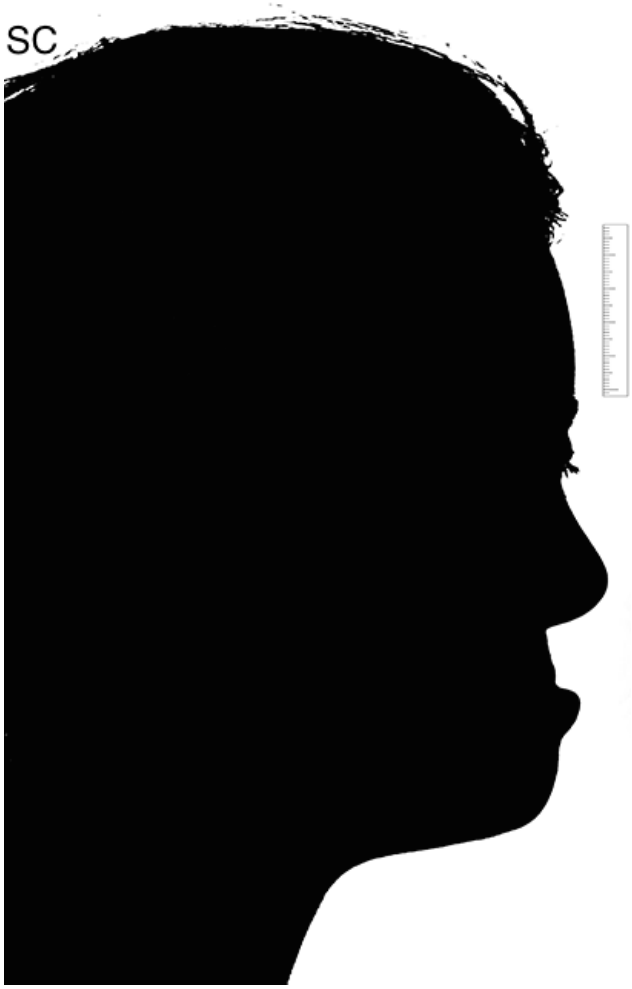
☐	☐	☐	☐	☐	☐	☐



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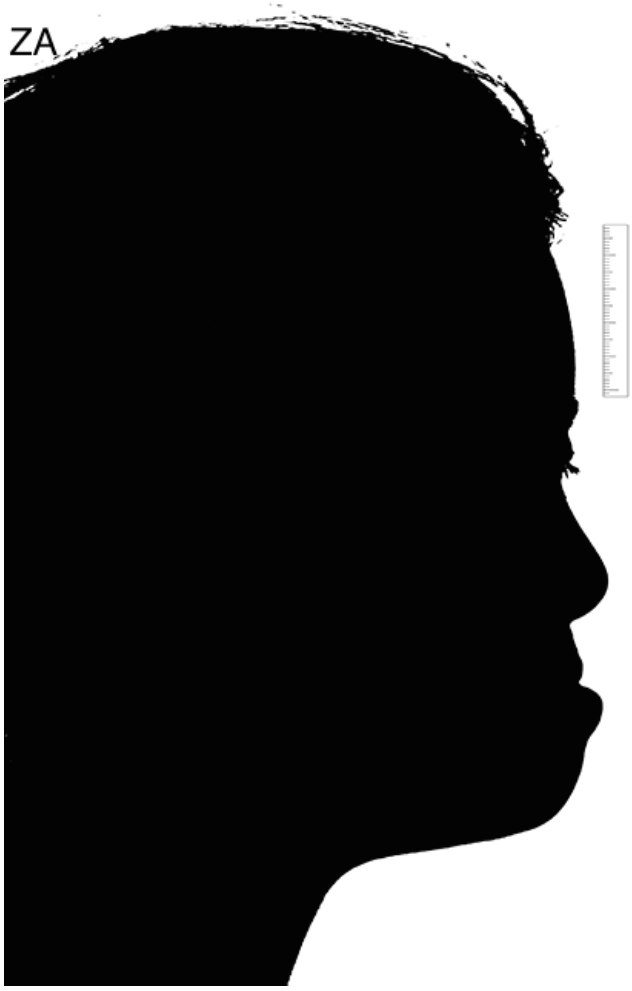

Silhouette of an adult Chinese female

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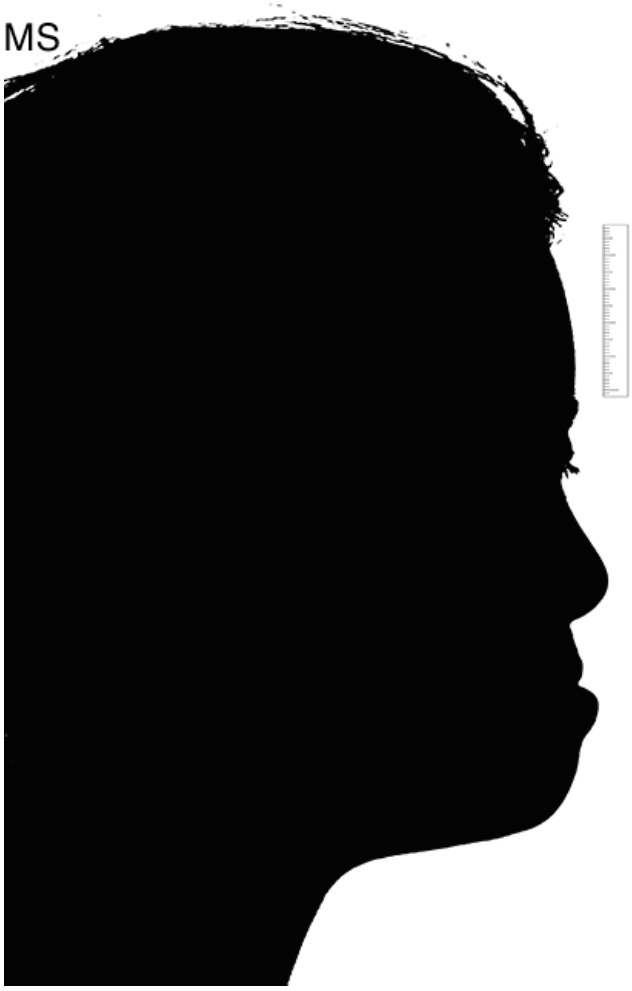

Silhouette of an adult Chinese female

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    - Yes
    - No

- How do you rate the level of attractiveness of this profile?

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
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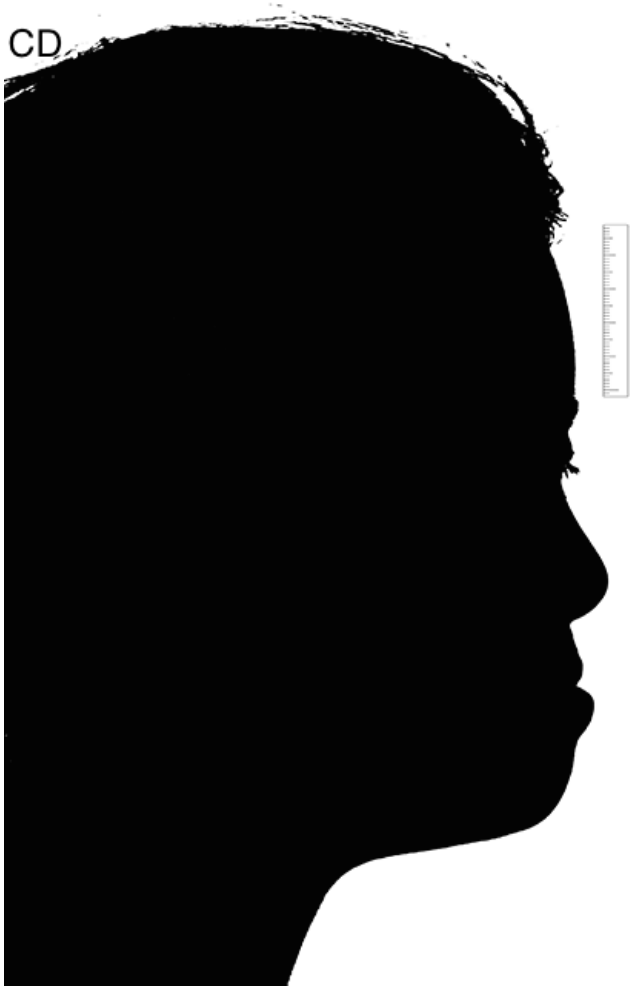

Silhouette of an adult Chinese female

- Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?
    - Yes
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- How do you rate the level of attractiveness of this profile?

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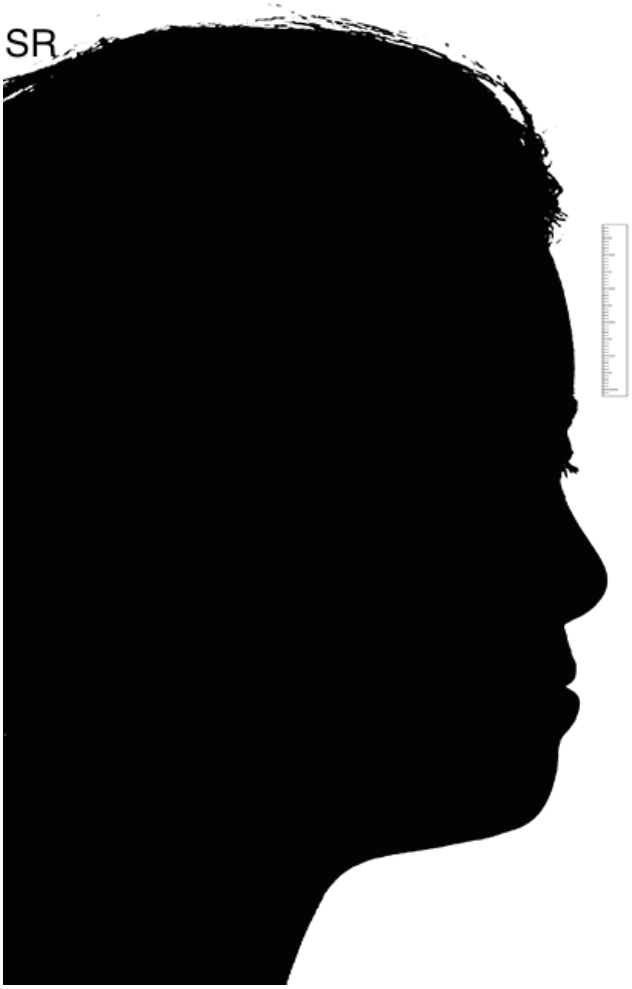

Silhouette of an adult Chinese female

- Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?
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    - No

- How do you rate the level of attractiveness of this profile?

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
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Silhouette of an adult Chinese female

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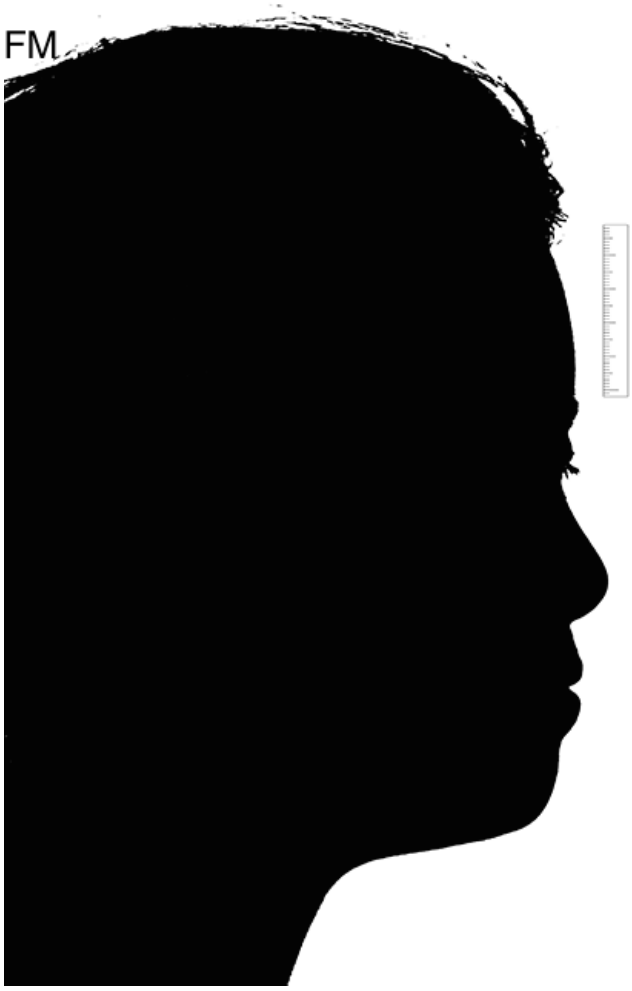

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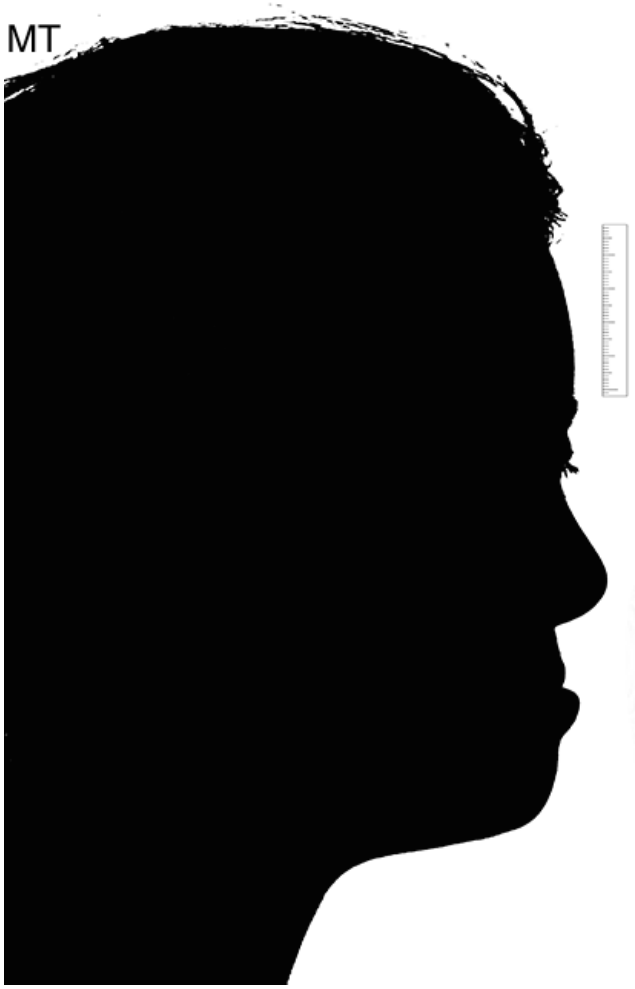

Silhouette of an adult Chinese female

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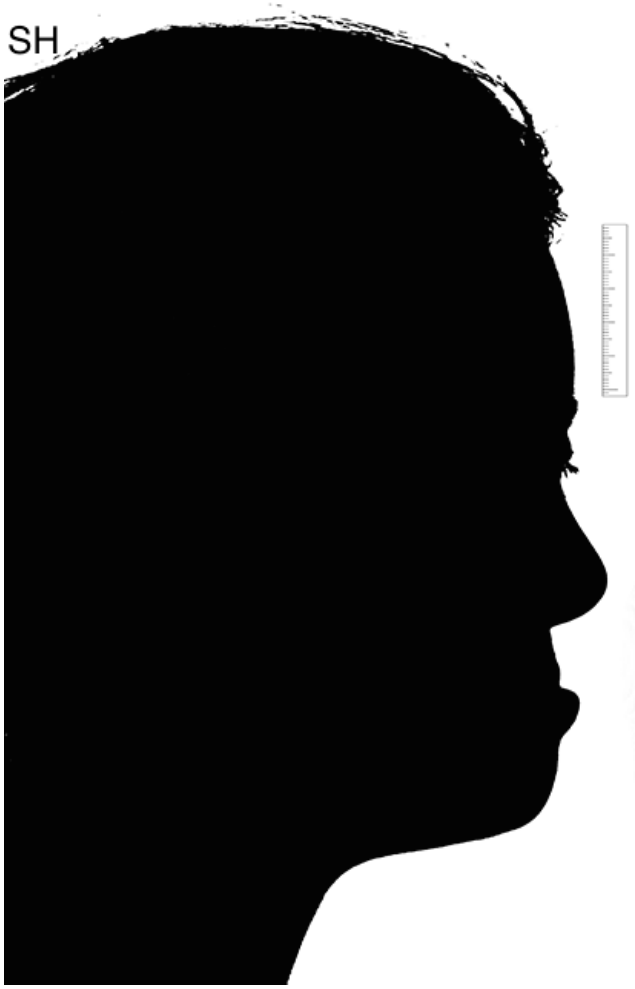

Silhouette of an adult Chinese female

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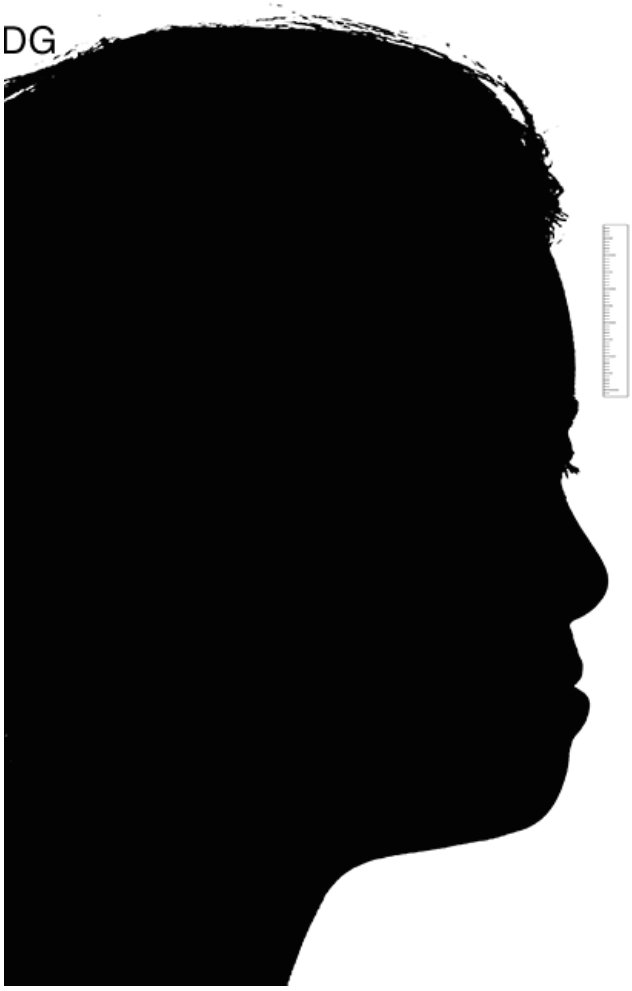

Silhouette of an adult Chinese female

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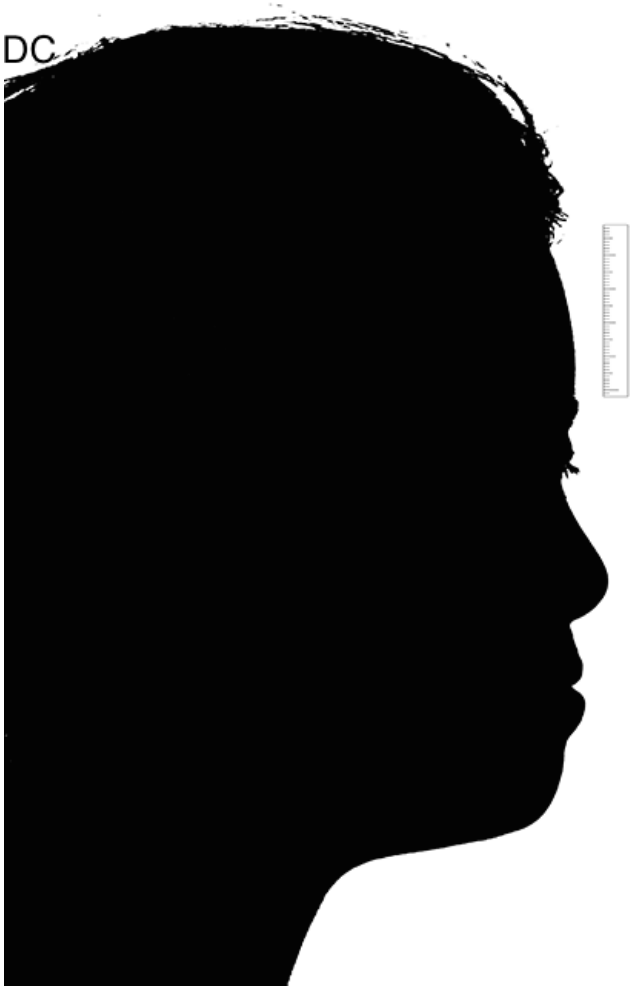
☐	☐	☐	☐	☐	☐	☐



Silhouette of an adult Chinese female

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☐	☐	☐	☐	☐	☐	☐

Thank you very much for your time